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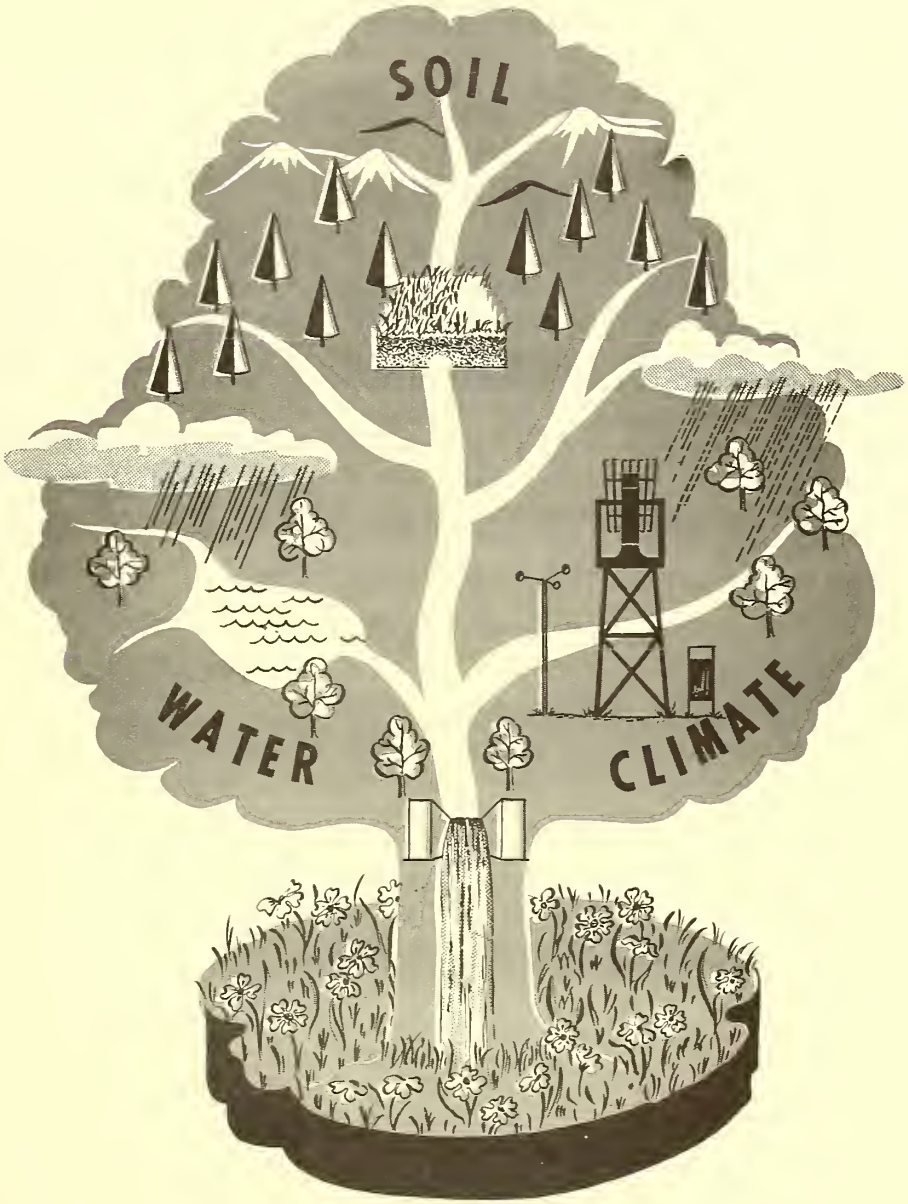
WATERSHED MANAGEMENT RESEARCH

Semiannual Report



U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

APRIL SEPTEMBER 1963

USE OF THIS REPORT

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Division of Watershed, Recreation, and Range Research
April - September 1963

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Division of Watershed Management Research

CENTRAL STATES FOREST EXPERIMENT STATION

April 1963 - September 1963

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Intermountain Forest and Range Experiment Station
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SEMIANNUAL REPORT
Division of Watershed, Recreation, and Range Research
April - September 1963

Washington Office

Still More Reorganization

The final step in the reorganization of Research in the W.O. is probably not news to most of you by now. About May 20 we became the Division of Watershed, Recreation, and Range Research with Herb Storey as Director of the combined Division. Ken Parker continues in charge of Range and Wildlife Habitat Research, Holscher in charge of Forest Soil and Water Research, and Hopkins has Forest Recreation Research. Other functions were also combined in this general reorganization so there are now only five Divisions reporting to the Deputy Chief for Research. In addition to our own these are: Timber Management Research, Forest Economics and Marketing Research, Forest Utilization and Engineering Research, and Forest Protection Research.

Forest Soil and Watershed Research

In discussing forest soil and watershed research programs and policies with some folks in the field, I find some lack of understanding and even apprehension about where we are headed with our forest soil and watershed research program. Several of you have asked about the policies of the W.O. on basic and applied research. You have been told by the Deputy Chief for Research, the Associate Deputy Chief, the Division Director, and Branch Chief that greater emphasis is to be given to basic research. Yet in speeches that are made and in papers that are written at the Washington level the emphasis always seems to be on problems of management. Yes, even the line project titles and descriptions are given a strong problem orientation. All of these points are true, so perhaps some explanation to clarify our thinking and yours is in order.

Broadly speaking, the program of the Forest Service in forest soil and watershed research is problem oriented. In all cases we should be trying to learn more about watersheds and the important factors that make them up in terms of water yield, soil stability and erosion, flood events, or soil development. Our purpose is to develop information and understanding of soil and watershed processes and to order this information into logical form to provide bases for decisions by managers of forest lands. Usually a problem is recognized by the Station Director or a member of his staff, as a result of their broad personal experience and their contacts with men whose job it is to manage forest lands. There is always more than one problem to be tackled, so the Director in consultation with the Division Chief and project leader selects the problem to be researched by the project staff. The project leader then

analyzes the problem and attempts to break it down into parts, and with his project staff they decide on a group of studies they will undertake to get answers to the problem.

The studies chosen depend upon the talents of project personnel, the facilities and funds available to do the research, and the nature of the problem. Most problems will require considerable basic research into the processes that go on within a watershed--seeking answers to how soils, plants, climate, topography, etc. affect watershed behavior and why. The amount of basic research depends largely upon you as a scientist, upon the facilities we are able to provide for you, and upon the judgment of the project leader as to how much basic research is needed. Some projects will do much more than others for the reasons given--available talent, money, facilities, and need.

Laboratory facilities are improving very rapidly--not as rapidly as we would like but rapidly nonetheless. The project staffs are becoming more and more talented to do basic research; most all of you have taken graduate study and are well versed in research techniques. The climate for basic research is better, and this means that we now draw away from the heavy emphasis on experimental watersheds as units of study and concentrate more on the unit factors in an attempt to understand how they work separately and with other factors to describe "what makes a watershed shed water."

When the Deputy Chief for Research says we will put more emphasis on basic research, he means it. But he does not mean that we will go all the way toward basic research. In the case of forest soil and watershed research it means we will ultimately devote 40-50 percent of our <u>overall</u> effort to basic research compared to the present 15-25 percent. The remaining 50-60 percent will continue to be addressed to applied phases of problems. The watershed will be used as a pilot test area in application of forest watershed practices.

So, we come right back to where we started. The Forest Service is in the soil and watershed research business to learn how watersheds function under management and to furnish information which will enable the Forest Service and the Department of Agriculture to carry out its mission of leadership in forestry--forest land management--nationwide. To do this job well and to give broader application to our findings, we must do basic research.

SEMIANNUAL REPORT

Division of Watershed Management Research

Central States Forest Experiment Station

April 1963 - September 1963

I. Forest Restoration and Watershed Management on Strip Mined Lands

by Robert F. May

A. Personnel

Recruiting personnel for the expanded program of research is underway. A team approach to the problem associated with reclamation is highly desirable.

Willis Vogel, a range conservationist, transferred from the Station's Columbia, Missouri, office to assist with revegetation studies involving grasses and legumes and wildlife habitat and game foods.

Dave Striffler is due to join the project in November, transferring from Lake States Station. He will handle the hydrology aspects of our program.

A soil scientist will be recruited to replace David Cummins who left in July to accept employment with the Georgia Agricultural Experiment Station. To complete the research team we are recruiting for a specialist in transportation engineering and/or soil mechanics.

In order to get the expanded project underway, we have employed two Berea College faculty members on a W.A.E. basis until permanent personnel are on the job. Tom Kemp, a sedimentary geologist, and Claude Gentry, a soil scientist-agronomist, are giving us much valuable assistance with our program.

B. Active Studies

Swell and Angle of Repose of Freshly Formed Spoil Banks from Rock-Soil Overburden. Surveys of coal seams in the Harlan, Kentucky, area have been completed. The swell factor was found to be 1.55 for the observations taken but individual measurements varied over a wide range. The angle of repose was found to be 37° (the same as for sand or gravel and clay mixtures) and varied within quite narrow limits from 34° to 40°. The most significant finding of the study, however, was the development of a prediction equation for determining the distance downslope from the coal outcrop that sidecast overburden would cover. This is important to watershed managers, as stream channels may be kept clear of spoil material if the mine pit is kept the prescribed distance upslope.

Strip Mining Effects upon Chemical Characteristics of Water in the Foresters Creek Watershed. Harlan County, Kentucky - This is an exploratory study to determine the chemical characteristics of the water in the stream at non-flood stage. A slight increase in the concentration of dissolved solids (from 50 ppm to 85 ppm) and specific conductance (78 epm to 134 epm) was noted during mining, but both decreased during the first half of 1963.

However, a second mining operation was begun by another operator on a second coal seam approximately 150 feet above the Harlan coal seam. We will continue collecting samples at 3-month intervals to assess the effects of multiple seam harvesting in a small watershed.

The Fertility Evaluation of Strip Mine Spoil from Certain Stratigraphic Horizons in Eastern Kentucky. Chemical analysis of the spoil before and after cropping and the plant tissue analysis from the first replication begun in January are now completed. This data will be supplemented by information from a second replication which will be completed before the end of the year. With data from both replications we will attempt to relate the dry weight yield of Balbo rye in terms of the variables: pH; specific conductivity; and available nitrogen, potassium, phosphorus, calcium, sodium, magnesium, iron and sulphur.

During the summer a student from Ohio State University gathered more than 1000 individual samples from highwall sections on six coal seams for a study to characterize overburden of certain coal seams. The samples are being crushed and pulverized in preparation for pH, sulphur, and iron determinations. This study is being made in cooperation with the Tennessee Valley Authority, Division of Forestry Development. They are making necessary chemical analyses, a sizeable contribution to the project. This study will pinpoint potential acid producing material in the undisturbed overburden.

Other studies begun during this report period are:

A replication of the study to Evaluate Some Plant Species for Late Summer and Fall Seeding to give a quick cover on strip mine spoil. In the initial trial the seeded species germinated but results are inconclusive due to the banks sliding down the hillside.

The Influence of Established Grasses and Legumes on the Survival and Growth of Trees Planted on Spoils in the Eastern Kentucky Coal Fields. Two hardwoods and two conifers are planted in an established cover of "Kentucky 31" fescue and serecian lespedeza. The growth and survival of these trees will be compared with similar plantings on spoils where the lespedeza and fescue had been removed.

Revegetating Long Outslopes by Seeding Grasses and Legumes Between Contour Plantings of Black Locusts and European Alders. The objective is to determine if a mixture of grasses (serecia lespedeza, crown vetch, alfalfa, birdsfoot trefoil and orchard grass) can be successfully established between rows of the planted black locust

and European alder. This may provide a quick temporary ground cover supported by a more permanent cover of trees and should materially reduce sheet and rill erosion on the long outslopes.

A replication of the Athens Research Center study, Selection of Alders for Spoil Bank Planting, was installed. This is one of four replications on spoils in the Central States territory. European alder (Alnus glutinosa) from 18 seed sources and 7 other species of alder were planted on eastern Kentucky spoil banks. Of three blocks planted, two were failures due to toxicity of the spoil banks. Although no formal measurements have been taken, survival on the third block appears to be fair.

The Evaluation of Some Plant Species for Spring, Summer, and Fall Seeding to Give Quick Cover on Strip Mine Spoil. Weeping lovegrass, crabgrass, and Kentucky 31 fescue seeded in the spring germinated and appeared to be well established after one growing season. Brown mustard germinated but quickly died out, crown vetch had low germination and grew slowly. Summer seeded species, German millet, Sudan grass, Kentucky 31 fescue, grain sorghum and crab grass had low germination and developed very slowly.

Seeding Versus Planting Shrub Lespedezas on Spoil Banks. This study has been initiated in cooperation with the Kentucky Department of Conservation. They are raising seedlings for this study at their Dawson Springs Forest Tree Nursery. Seed from the same lot will be sown in the spring of 1964 when the seedlings are set out.

C. Studies planned to get underway during the next six months include:

Adaptation Trials of Aquatic and Shoreline Vegetation in and Around Ponds on Strip Mined Areas in Eastern Kentucky.

Erosion of Abandoned Coal Haul Roads.

Changes in Chemical Characteristics of Coal Strip Mine Spoil Surface with Time.

Hydrologic studies may include the hydrology of strip mine ponds; the studies of the sedimentation from strip pits, spoil banks, and access roads.

Other revegetation studies may include shrub adaptation trials, seedings of native grasses, and plantings of selected poplar clones.

An inventory of strip mines in selected counties will be made to assess bank characteristics, mining methods, road systems, watershed conditions, revegetation treatments, and post mining uses by man and wildlife. We expect to use much of the data as an index for future strip mine research.

The Beaver Creek Administrative Study with seven federal and four state agencies was placed on a stand-by basis, to be activated after a 4 or 5 year period. However, it has just been reported that

additional mining (augering of the exposed seam) may get under way. Instrumentation has recently been activated by the U.S. Geological Survey units participating in the study.

D. Cooperative Aid Studies

The strip mined area restoration project is involved in two cooperative aid studies underway with land-grant universities in the Midwest. They are:

Ohio State University - Develop methods of determining, and establish the factors which influence the structural stability of the overburden of the Lower Kittanning Coal Seam in the Ohio Valley.

Purdue University, Indiana - Determine cover type utilization by cottontail rabbit in Southern Indiana coal stripped lands.

E. Manuscripts

May, Robert F.
Strip Mine Reclamation: A Continuing Challenge to Research.
Coal Age.

II. Nuclear Equipment Evaluation by Richard B. Marston

A. Inventorying Stockpiled Coal with Surface Moisture and Density Nuclear Meters

In October 1962, surface moisture and density nuclear meters were compared with gravimetric samples in an inventory at the Ohio Power Company's stockpile of coal at their Muskingum River thermoelectricity generating plant near Beverly, Ohio. The results suggest that after careful calibration the nuclear method could be easier and faster than the gravimetric sample method for estimating the moisture and density of the stockpiled coal.

The California sand cone method and gravimetric samples secured with a post hole auger have been used for estimating the density and moisture, respectively, in previous inventories of this coal stockpile. Such measurements have been obtained from the bottom of 2 to 4 foot deep pits cut into the surface of the coal with a bulldozer.

Measurements and samples were taken from 15 such shallow pits on this coal pile in October 1962. Moisture and density nuclear meter readings were then made on a surface adjacent to that used for taking the sand cone measurement and the gravimetric sample.

The density as determined from the 15 California sand cone measurements ranged from 68.8 to 86.8 and averaged 79.8 pounds per cubic foot. The moisture content of the 15 gravimetric samples varied from 5.1 to 10.2 and averaged 8.3 percent on an oven-dry

weight basis. The range in values for both density and moisture are relatively narrow and the nuclear probes are capable of measuring much wider ranges than these.

The simple linear correlation between the surface density nuclear meter readings and the densities determined by the California sand cone gave a correlation coefficient of 0.452. This is statistically significant at about the 90 percent probability level. The correlation coefficient between the surface moisture nuclear meter reading and the gravimetric moisture samples was only slightly higher, 0.456. This was also statistically significant at the 90 percent probability level.

Since sampling with the nuclear meter would not require that pits be opened with a bulldozer or that the samples be processed in the laboratory, it appears that this method would be a better way of sampling moisture and density of stockpiled coal. No doubt the accuracy of nuclear meter sampling could be greatly improved over that found in this study if additional calibration measurements were obtained.

B. New Equipment and Developments

The Chief of the Hydrologic Laboratory, A. Ivan Johnson, U.S. Geological Survey, Federal Center, Denver 25, Colorado, has called to our attention developments in equipment for measuring depth soil density and moisture. Johnson is Chairman of the ASTM Committee to recommend practices for use and calibration of commercially available nuclear equipment that measures depth soil moisture and density. We were informed on tentative results from a 21-page questionnaire the ASTM Committee had sent out to agencies and companies using nuclear equipment. It was interesting to learn there are eight companies producing nuclear soil moisture equipment in the U.S. and about ten in Europe. There are three companies working on new models and these are not Troxler, Nuclear of Chicago or work by the Ohio Engineering Experiment Station.

The Well Reconnaissance Company, Inc. at Dallas, Texas, has developed a portable meter with a recorder. According to Ivan, as the probe is lowered into the hole a continuous profile can be obtained on a recorder chart. This instrument can be equipped with a 2,000 foot cable so it would be possible to log several holes from one location.

III. Subsurface Water Management by Ronald Z. Whipkey

In June Whipkey returned full time to the subsurface stormflow project at the New Philadelphia Field Office after spending three quarters at Ohio State University. The ensuing three months were spent in enlarging and improving the plots, rainmaker systems, collector trough system, and in making runs. We feel we now have a good system for studying water movement under our soil conditions.

Dick Marston has added neutron meter access tubes to the stormflow plots, one to each tensiometer battery. He hopes to find if there is a relationship between soil moisture content and hydraulic head at the rather moist conditions under which the plots are operated. Dick found out the open-ended tubes have served as piezometers after most of the runs. The tubes terminate in heavy clay at 48 inches and water has risen as high as 18 inches in the first or lower access tube.

After pumping the pipe, this level will recover almost fully in 30 to 40 minutes--this confirms a temporary ground water table that is shown by the tensiometers. In most cases the water levels have receded by the following morning.

In past runs we have suspected that much of our flow may have come from the heavily-wetted lower portions of the plot. We felt the possibility existed that the moisture from the upper half might diffuse laterally into surrounding dry soil, or follow root channels into the impeding soil strata, thus bypassing the collection system. To test this we wetted the upper 10 to 15 feet of the 50-foot long plot, leaving the lower 30 to 35 feet dry. The movement of the water could be followed down the plot by the lowered tensiometer readings. In almost every case seepage occurred from the collection system several hours after the run started, indicating that the upper portion of the plot does drain into the collection system. In all runs seepage occurred only from the trough immediately overlying the water-impeding strata.

We are now working up the runs and the results are scheduled for publication next year. We had hoped to report in this edition on our experience with the double-tube hydraulic conductivity equipment. So far, we have not had time to develop operational procedures, but expect to have preliminary results before the end of October.

SEMIANNUAL REPORT
Division of Watershed Management Research
Intermountain Forest and Range Experiment Station

April - September, 1963

DIVISION

This summer has been a busy one, marked by considerable field activity. Several new studies were begun and old ones continued with the assistance of more than a dozen summer student assistants.

Harold Haupt completed his move to Moscow, Idaho, as leader of Project 1601. He spent a full summer becoming acquainted with his new project area. Robert Merriam accepted a transfer to the Pacific Southwest Station, and, upon completion of his graduate work, will be stationed in Hawaii.

Otis Copeland attended the Kepner-Tregoe training course for 1 week in Denver.

This Division, representing the Intermountain Station, sponsored a tour of the Davis County Experimental Watershed for members of the Soil Conservation Society of America following their annual meeting at Logan, Utah.

Publications

Haupt, H. F., and W. J. Kidd, Jr. 1963. Laboratory methods for determining the downward movement of seed on road fills. U.S. Dept. Agr., Forest Serv., Intermountain Forest and Range Expt. Sta., Res. Note INT-2, 7 pp., illus.

Kidd, W. J., Jr. 1963. Soil erosion control structures on skidtrails. U.S. Dept. Agr., Forest Serv., Intermountain Forest and Range Expt. Sta., Res. Paper INT-1, 8 pp., illus.

Packer, Paul E. 1963. Soil stability requirements for the Gallatin elk winter range. Jour. Wildlife Mgmt. 27: 401-410.

1601 - SNOWMELT FLOOD AND SEDIMENT REDUCTION PROJECT

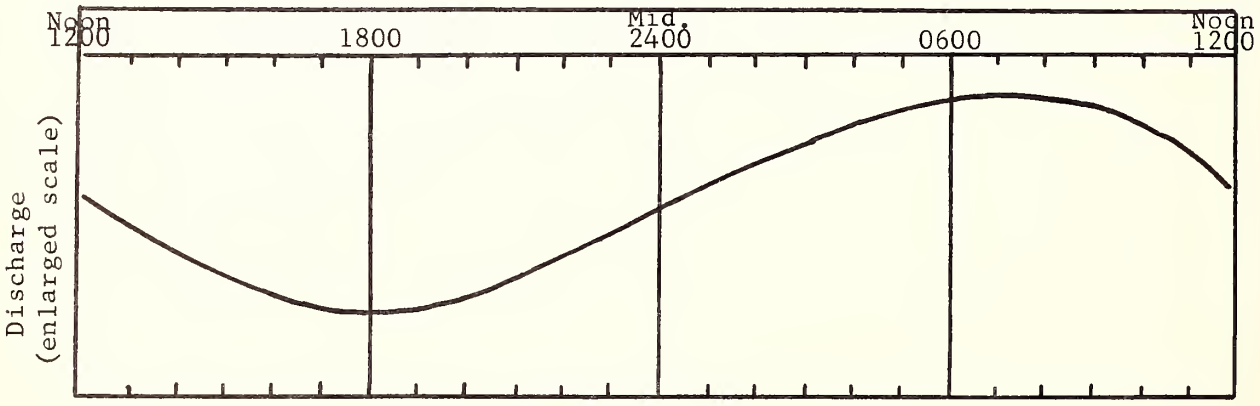
Major effort this past season has been directed to the hydrology of the soil mantle in a mature spruce-fir forest. Ed Burroughs and his crew have been spearheading this work out of Missoula. Haupt was getting settled in the new lab at Moscow, becoming acquainted with a new region, and attempting to maintain a manuscript schedule.

Measuring Seepage Flow and Transpirational Draft

This study was established to determine the effects of logging roads on subsurface water. Secondary objectives are to measure groundwater seepage from logging road cut banks, and, from these data, to estimate the transpiration of the forest type and total seepage from road cuts. The study area consists of six 4-acre blocks: three clear-cut blocks and three blocks with a spruce-fir forest of 11,000 board feet per acre. Three contractor-built roads, 200 feet apart, were constructed on the contour through two clear-cut and two forested blocks. A measurement zone 100 feet wide, centered in each block, is used for soil moisture and seepage flow measurements.

Seepage flow is diverted by a 100-foot galvanized iron trough placed against the bottom of the road cut in each measurement zone. At the lower end of the trough, a Parshall flume and water level recorder provide a continuous record of head on the flume. For discharges too small to be measured accurately by a 1- or 2-inch flume, inserts are used to convert the flume to an orifice-type measuring device. The small orifices were more sensitive to change in discharge rate.

Diurnal fluctuations on the recorder charts were attributed to transpirational draft by the forested areas above the road. Chart records show that the greatest daily discharge occurs around 0800 hours, decreasing at a gradual rate to a minimum around 1830 hours. During early evening, seepage flow gradually increases, as illustrated in the following sketch.



Transpiration draft for a 100- X 200-foot forested zone between two roads is shown below:

Seepage flow - time and date		Transpirational draft	
Maximum	Minimum	Cu. ft./day	Cu. ft./acre/day
0530 - July 20	1900 - July 19	3.61	7.86
0800 - July 25	1930 - July 24	6.29	13.69
0800 - July 25	1730 - July 25	3.26	7.10
0800 - July 29	1800 - July 30	4.47	9.74
0830 - August 1	1600 - August 1	3.35	7.29

Mean transpirational draft represents 9.14 cubic feet per acre per day.

Seepage flow records from four 100-foot road sections were used to determine total seepage flow for 37 consecutive days from July 3 to August 9, 1963. The snowpack had melted by June 1; therefore, this record excludes the large seepage flow rates from snowmelt. Total flow from 1,250 square feet of roadbank for this midsummer period was 17,174 cubic feet--almost one-fourth-acre foot. For insloped roads, this drainage would be diverted along the inside ditch to a culvert or stream channel and be lost from the soil mantle. For outsloped roads, this drainage would be returned to the soil mantle below the road--minus the quantity lost by evaporation. If the records for these four 100-foot road sections can be accepted as representative, then the hydrologic effect of logging roads may be extremely important.

Mapping Bedrock Topography

As this report is being written, mapping of bedrock topography and the confining soil layers is progressing in the six treatment blocks. Seismic refraction and resistivity techniques are being employed to define the subterranean profile. To do this job, we contracted the job with the geological crew from Region 1 Engineering. The depth of residual material formed on granite bedrock ranges downward from 6 feet--the maximum penetration of the neutron moisture tubes--to an unknown depth. The seismic estimates have an accuracy of $\pm$ 10 percent for bedrock depth. The plan does not call for confirmation by core drilling. It is hoped that these profile data will help explain the persistence of a seep in one clear-cut, roaded block while in other blocks, surface seepage disappeared by midsummer. Preliminary readings from four seismic transects run in this block show that bedrock begins at 35 feet at the uphill end of the block and inclines to 9 feet in the proximity of the active seep.

Modifying the Neutron Probes

Up until this spring, our two Troxler soil moisture probes had been inoperative from time to time because of malfunctions. One source of trouble was the recurrent failure of the scaler-to-probe cable. Prior to modification, it was seldom that more than 600 readings could be taken before cable failure. Since modification, over 10,000 readings have been taken without a cable failure.

Bland Richardson, our forestry research technician, attributed the trouble to the fact that while handling the cable and flexing it, the strands move back and forth within the rubber-covered sheath. When the cannon plug is attached to the probe, movement of the strands cause them to kink at the clamp on the plug or at the soldered connection within the plug. This results in breakage of one or more strands within the cable.

The modification allows for space within the conduit for the strands to move without resulting in a kink. The compression nut when tightened on the compression seal offers resistance to the movement of the strands within the rubber sheath. Any movement which passes the compression seal is taken up within the conduit. When assembly is complete, the preamplifier is rigidly attached to the rubber sheath of the cable. Richardson has the specifications for the new parts if anyone is interested.

Harold F. Haupt
Edward R. Burroughs, Jr.

Some Snowmelt Characteristics of a Western White Pine Forest

(The following contribution represents work that Paul Packer had underway before he was transferred to Project 1603.)

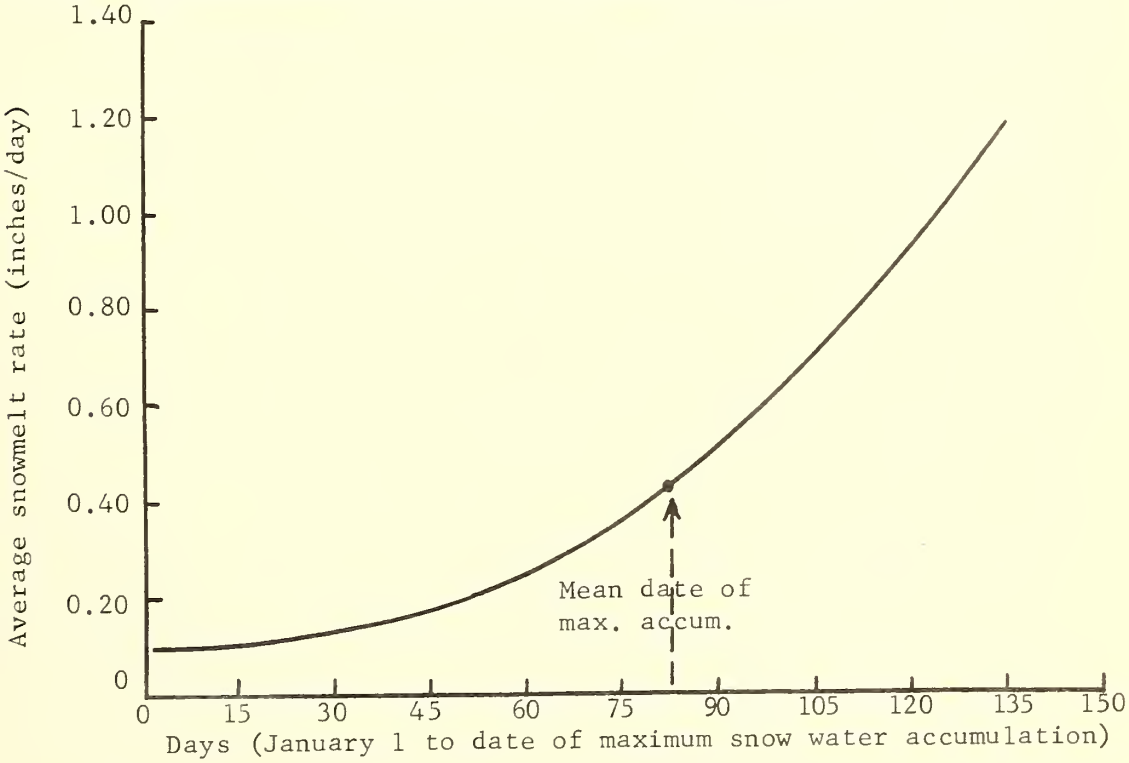
The most important watershed management problem in the Upper Columbia River Basin of northern Idaho and western Montana is how to continue to harvest timber of good quality and sufficient quantity without aggravating snowmelt flood and sediment discharges. Solution of this problem depends upon knowledge of the accumulation and melt characteristics of the winter snowpack and of the manner and degree in which these characteristics may be altered by timber cutting on different forest sites.

Effects of elevation, aspect, and forest cover conditions on maximum accumulation of snowpack water in a white pine forest in northern Idaho were reported in detail in Forest Science for September, 1962.

Recent analysis of the snowmelt characteristics of this same white pine forest indicates that the average snowmelt rate between the time of maximum snowpack accumulation and the time the snowpack disappears is influenced chiefly by one climatic factor and four site factors. The climatic factor and the elevational site factor explain the most variance in average snowmelt rate. The density of the forest canopy--hence, by inference, the effect of timber cutting--explains more snowmelt variance than any of the other site factors.

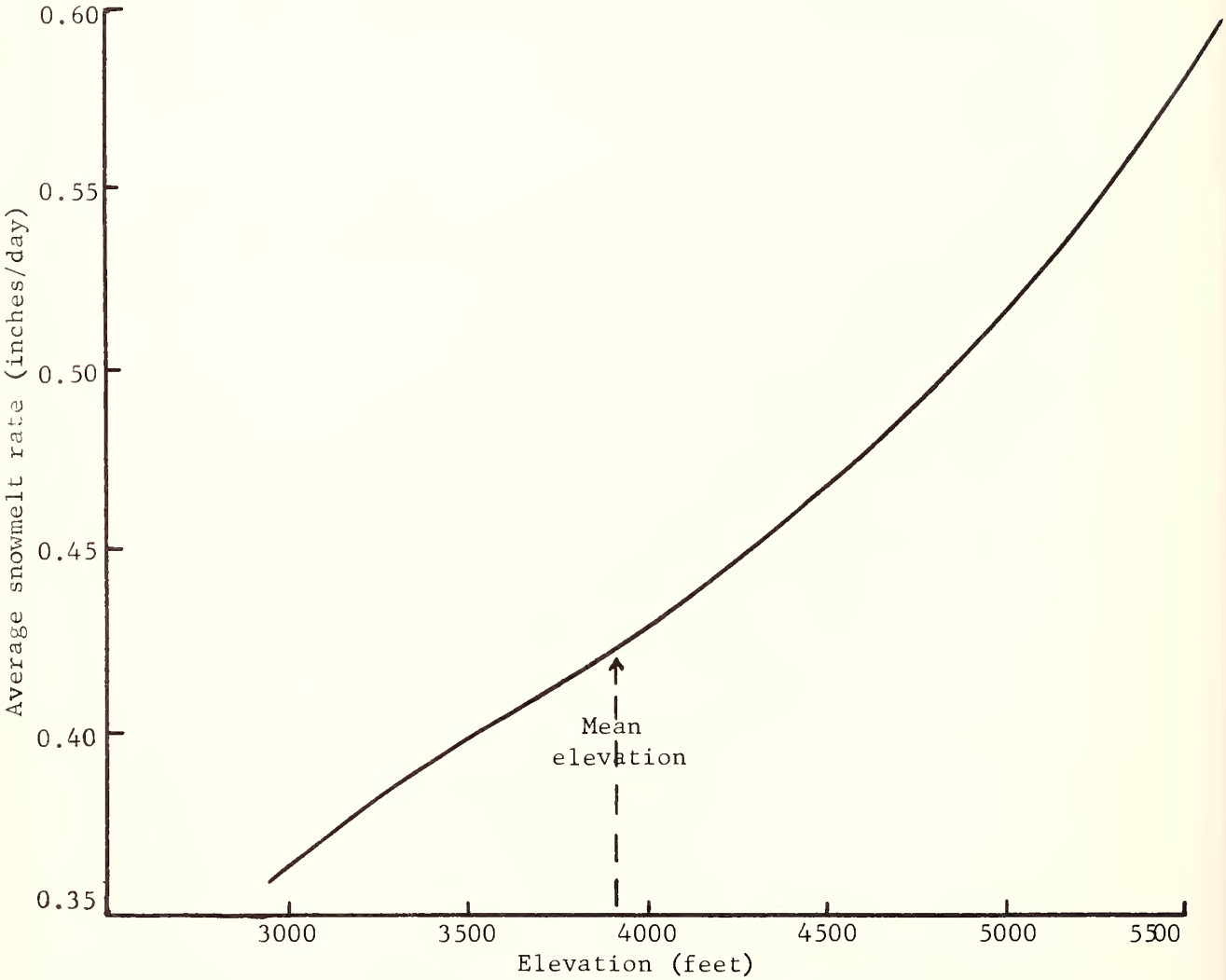
Effects of individual factors on snowmelt are discussed below in greater detail:

1. Effect of delay in time of maximum accumulation after January 1. The average daily snowmelt rate over the entire Experimental Forest during 4 years of study was 0.42 inch per day. The rate at mean elevation of 3,656 feet, mean aspect of 281 degrees, mean slope of 37 percent, and under mean forest canopy density of 45 percent, increased from 0.10 inch per day when melting began as early as January 1 to 1.20 inches per day when beginning of melt was delayed 135 days or until about May 15 (see following sketch). The increase in average snowmelt rate with delay in the time at which melting began, reflects the effect of warmer temperatures as the spring season progressed.



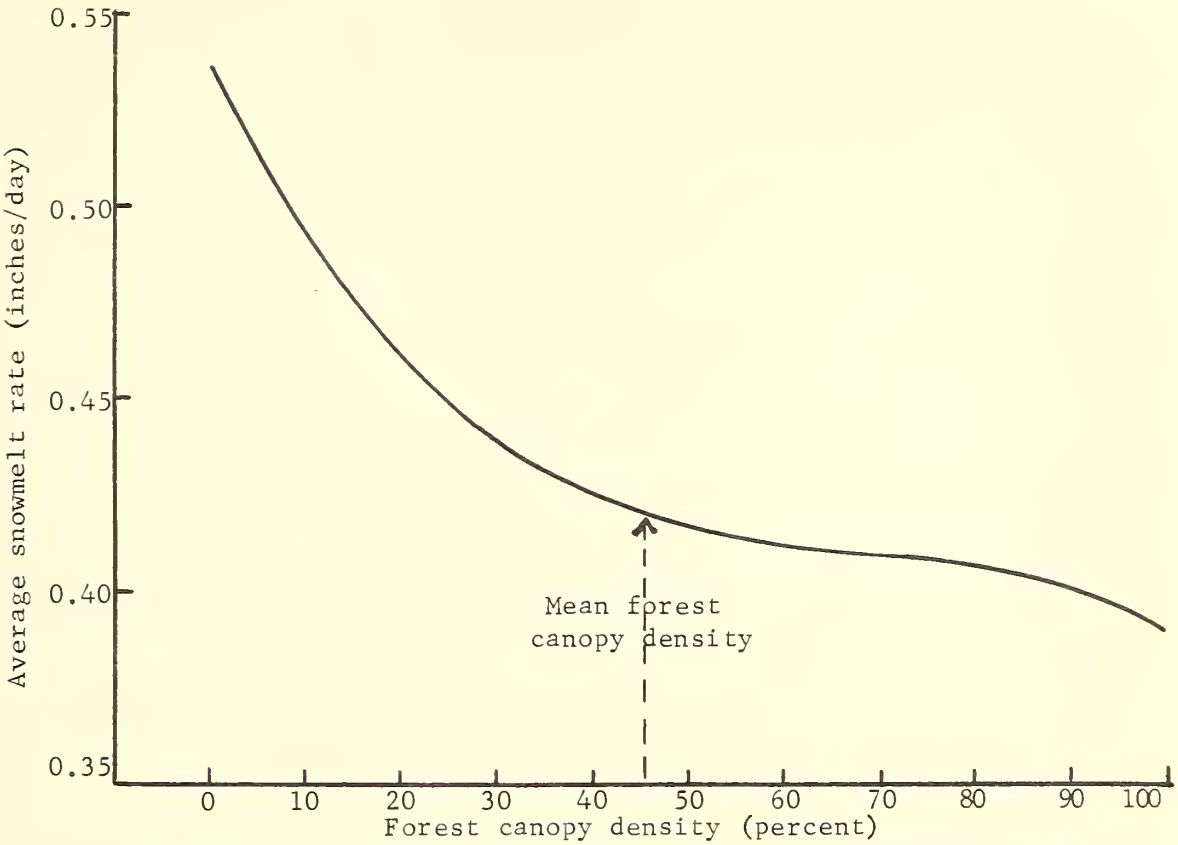
Relation of Average Daily Snowmelt Rate to Date of Maximum Snow Water Accumulation at Mean Elevation of 3,656 Feet, Mean Aspect of 281 Degrees, Mean Slope of 37 Percent, and Mean Forest Canopy Density of 45 Percent.

2. Effect of elevation. The average daily snowmelt rate on mean aspect (281°), mean slope (37%), under mean forest canopy (45%), and on the mean date of delay in beginning of melt (March 20), increased from about 0.36 inch per day at 2,700 feet to about 0.63 inch per day at 5,500 feet (see following sketch). The increase in average melt rate with increasing elevation is due to the greater depth of accumulation of snow with increasing elevation, which leaves more snow subject to late spring warm temperatures at higher rather than at lower elevations.



Relation of Average Daily Snowmelt Rate to Elevation at Mean Aspect (281°), Mean Forest Canopy Density (45 Percent), Mean Slope (37 Percent), and Mean Date of Maximum Snow Water Accumulation (March 20)

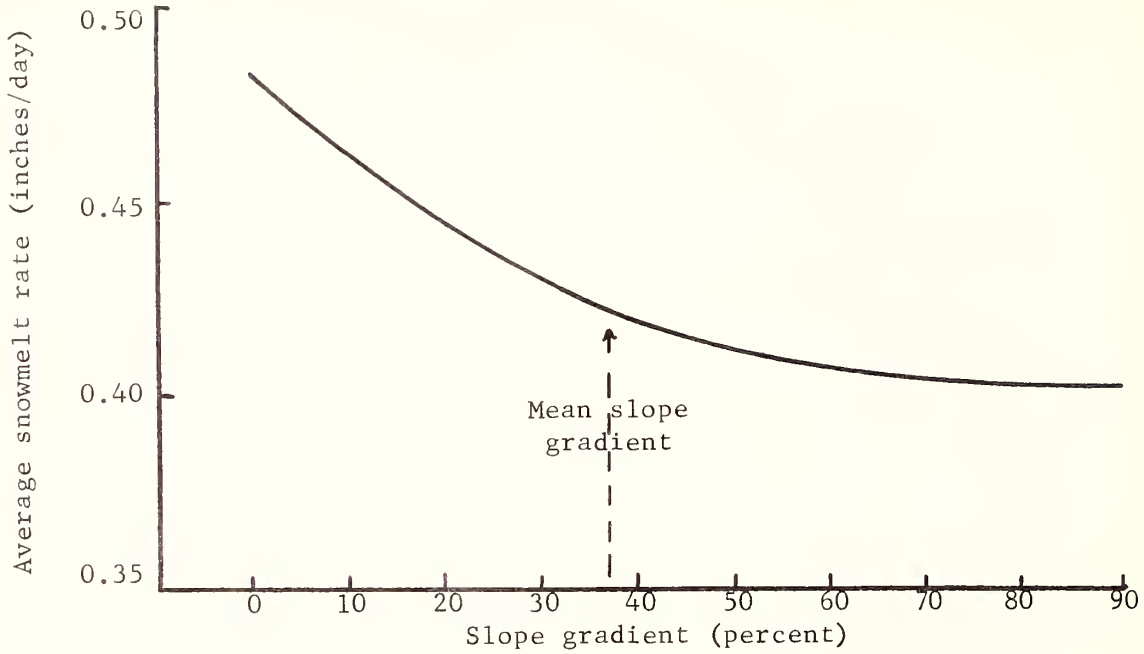
3. Effect of forest canopy. The average melt rate at mean elevation, mean aspect, mean slope, and mean date of delay in beginning of melt, increased from about 0.39 inch per day in dense forest stands of 100-percent canopy to 0.54 inch per day in clear-cut openings (see following sketch). The second derivative of the equation for this



Relation of Average Daily Snowmelt Rate to Forest Canopy Density at Mean Elevation, Mean Aspect, Mean Slope, and Mean Date of Maximum Snow Water Accumulation

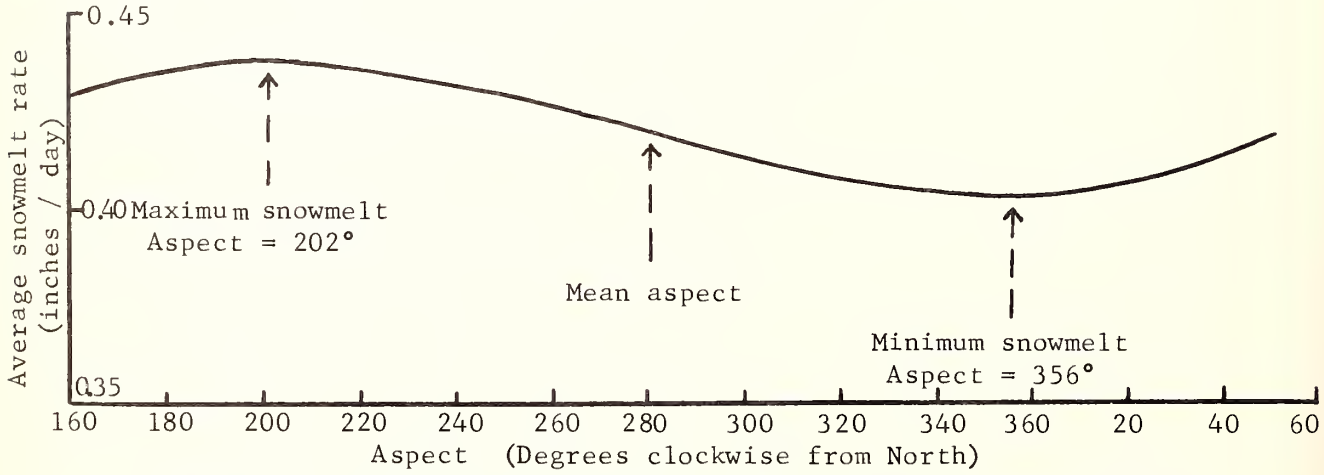
relation indicates that the increase in melt rate accelerates rapidly when the forest canopy is reduced below a density of about 67 percent. This means that timber cutting, which manipulates the forest canopy between densities of 100 and 67 percent, has less effect in increasing snowmelt rates compared to cutting that reduces the canopy below 67 percent.

4. Effect of slope. The average snowmelt rate at mean elevation, on mean aspect, under mean forest canopy, and on mean date of delay in beginning of melt decreased from 0.46 inch per day on 10-percent slopes to 0.40 inch per day on 90-percent slopes (following sketch). Further analysis of the interactions between slope, aspect, and forest canopy density are needed to understand this effect. Preliminary indications are that aspect has a decreasing effect on snowmelt rate as the slope increases.



Relation of Average Daily Snowmelt Rate to Slope Gradient at Mean Elevation, Mean Aspect, Mean Forest Canopy Density, and Mean Date of Maximum Snow Water Accumulation.

5. Effect of Aspect. The average snowmelt rate at mean elevation, mean slope, mean forest canopy, and mean date of delay in beginning of melt, decreased from a maximum rate of 0.44 inch per day at an aspect of 202 degrees to a minimum rate of about 0.40 inch per day at an aspect of 356 degrees (following sketch). The difference is larger on slopes less than the mean slope of 37 percent but becomes smaller on steeper slopes.



Relation of average daily snowmelt rate to aspect at mean elevation (3656 feet), mean forest canopy density, mean slope, and mean date of maximum snowwater accumulation.

Paul E. Packer
Edward R. Burroughs, Jr.

1602 - SOIL STABILIZATION PROJECT

Logging Compartment Study

This study on the variable effects of logging methods on erosion was established in the Deep Creek and Oompaul Creek drainages of the Zena Creek logging study area. Sediment is measured in small watershed dams and from 1/100-acre plots. The Deep Creek drainage was logged in the fall of 1962. Sediment yields are as follows:

Type logging	Number dams	Average tons/sq.mi. 5/28 - 7/18	Number plots	Av. tons/sq.mi. 5/28 - 7/12 Before logging	Av. tons/sq.mi. 5/28 - 7/12 After logging
Jammer	3	1/ 213	5	0	7.8
Mobile spar-skyline crane	5	2/ 25	8	0	17.3

1/ All erosion occurred from fill slopes and deposited in one dam.
2/ All erosion occurred from skidtrails and deposited in one dam.

The Oompaul Creek drainage has not yet been logged. Although the runoff plots show evidence of some erosion, we believe it is mostly due to rain splash and soil movement from gopher casts. Sediment production figures for the period May 28 to September 12 are tabulated below:

Area	Number dams	Average tons/sq.mi.	Number plots	Average tons/sq.mi.
Jammer	5	0	6	16.3
Mobile spar-skyline crane	3	0	5	1/ 22.4

1/ This figure does not include one plot from which the very high sediment yield (556.8 tons/sq.mi.) was due to extremely heavy use by elk and deer.

Tailholt Creek - Circle End Creek Watersheds

Much of the late summer was spent in enlarging the capacity of the Tailholt Creek sediment basin. As a result of our work, the basin's capacity has been almost tripled. Bedload sediment trapped behind Tailholt and Circle End dams during the period May 15 - September 4, 1963, amounted respectively to 8.2 tons per square mile and 2.2 tons per square mile. Suspended sediment samples taken during the peak flow period (March 21 - April 25) showed that Tailholt averaged 64 ppm. in comparison with 37 ppm. for Circle End.

Roadfill Stabilization

Although several of the roadfill plots were destroyed by the 8-inch October rain last fall, soil samples were again taken this summer (after a 1-year interval) to measure several physical and chemical characteristics of the fill slope at several depths.

Although all analyses are not completed as yet, some very tentative results are available. The final report on this study will be a Master's thesis by C. A. Ohlander, our summer assistant for the past 3 years.

Tentative results are listed without further comment. During a 1-year period, the following changes took place:

1. Bulk density increased slightly but not significantly.

2. An extremely small increase in nitrogen occurred in the 2- to 12-inch layer.

3. Cation exchange capacity increased.

4. pH values decreased slightly.

The steep topography in the mountainous portion of Idaho is characterized by seemingly violent contrasts in forest cover related to climatic exposure of the terrain. To assess the effect of exposure, we initiated two studies: 1602-208 (Soil moisture changes related to exposure) and 1602-209 (Influence of logging and exposure on infiltration).

Soil Moisture and Exposure

In this experiment, north and south exposed areas were located on opposite sides of a ridge line at an elevation of approximately 5,200 feet. Soil samples were collected at 3-week intervals. Although the data have not been fully analyzed, it appears that the south exposed area became drier than the north area, but that both dried out beyond their respective wilting points. Further, the water-holding characteristics of north and south exposed soils are not the same; one-third and 15 atmosphere values of soils on north exposures exceed the values for soils on south exposures.

Following are average values obtained this summer:

Soil depths Inches	Exposure	Percent moisture content on indicated date 6/26	7/17	8/8	8/29	9/19	Percent moisture at 1/3 atm	15 atm
0-2	N	17.6	3.8	1.4	2.9	8.7	8.1	5.0
	S	20.0	2.2	0.4	0.8	10.2	7.3	4.3
5-7	N	17.3	5.0	3.5	2.4	5.9	7.5	3.9
	S	11.5	4.7	2.0	1.6	8.9	4.6	2.2
11-13	N	13.6	7.4	2.6	2.8	2.7	6.8	2.8
	S	9.3	5.6	2.5	1.8	7.5	4.4	2.3

Effect of Logging and Exposure on Infiltration

This study was conducted together with Richard Meeuwig and his infiltrometer crew. Plots were located on logged and unlogged areas and on northwest and southwest exposures. The complex analysis has not yet been completed, but we feel sure that infiltration values are related to exposure and a strong possibility exists that infiltration values may be related to logging. In the following tabulation, each figure represents runoff (in cc) during the last 5 minutes of a 30-minute uniform application of rain on a 2- by 3-foot plot.

Exposure	Logged	Not logged
NE	474	589
SW	3,020	1,670

Other infiltration tests were conducted on road fills and cuts. In these tests we found that on a road surface completely benched by virtue of a deep cut, greater runoff occurs from the edge of the road in contrast to the center; on a road section derived completely of fill material, runoff rate is similar from both center and edge of the road. These conditions are illustrated in the following tabulation in which each figure represents runoff in cubic centimeters during the last 5 minutes of a 30-minute uniform application of rain:

	Road fill	Road cut
Center of road	4,137	4,158
Edge of road	3,975	4,642

Watershed Rehabilitation and Cover Restoration on Morehead Mountain, Boise National Forest

This year's safari into Morehead Mountain included Paul Packer, Ned Bethlahmy, Harold Haupt, and Joe Kidd, all of the Intermountain Forest and Range Experiment Station, and Don Seaman of the Boise National Forest.

While Don and Ned remeasured some Parker three-step transects established in 1953, the others remeasured the intertrench plot transects established in 1956. Unfortunately, two of the three Parker three-step transects were destroyed by bulldozers when the contour trenches were constructed in 1956. Remeasurement data on the eight intertrench plots indicate a small decrease in total ground cover. This decrease has not yet been evaluated statistically. The 3.3-percent decrease from 1962 was occasioned by less litter, Carex, and grass cover; in contrast, forb cover increased slightly.

Nedavia Bethlahmy
W. Joe Kidd, Jr.

1605 - WATER YIELD IMPROVEMENT PROJECT

With three scientists now working on this project, we have spread out somewhat. Instead of concentrating all of our efforts on the Davis County Experimental Watershed, one of our men has begun extensive studies at the Great Basin experimental area near Ephraim, Utah. Thus, our report this time will relate to activities at these two areas.

Davis County Experimental Watershed

Not since the days of Bailey, Croft, and Craddock has such a crew of men spent the summer at Farmington. The Water Yield Project had seven men working in the mountains, and the Range-Watershed Rehabilitation Project had two men there.

Because we're concerned with water, it may be of interest to point out that Davis County Experimental Watershed (as did most of northern Utah) experienced some rather peculiar precipitation patterns this year. The early and midwinter months saw so little snowfall that prospects for a dry summer looked very good, but in April and May record amounts of precipitation fell in this part of the State. As the summer wore on, however, a genuine drought developed, and it was late in August before the first rain fell since June. In September, we tallied a record amount of rainfall, if our rain cans are correct.

Dale Pfankuch and his crew continued to obtain free-water evaporation data for the second year from 12 climatic stations scattered from the Salt Lake valley to the top of the Wasatch range. First-year results of this cooperative study with the U.S. Weather Bureau were presented this summer at the I.U.G.G. meetings in Berkeley in a paper co-authored by Eugene Peck of the Weather Bureau and Dale Pfankuch.

My own study of precipitation disposition in the aspen type continued at the Parrish plots. When our last report was made, I was up top measuring snowpack evaporation; and results from that trip lead us to believe that total winter snowpack water loss due to evaporation may exceed the 3 inches that Croft and Monninger estimated for northern Utah.[1/] We used lucite cylinders, 6 inches in diameter, and found these to work well.[2/] The coming winter will find us spending at least 3 weeks tramping around in the snow, obtaining more evaporation data.

Evapotranspiration losses between June 6 and September 4 of this year were 22.2 inches from the aspen-herbaceous stand and 16.9 from the herbaceous stand. From the aspen stand, this amounts to nearly 0.25 inch per day, and it comes to about 0.19 inch per day for the herbaceous cover. These data are losses that occurred in 10 feet of soil profile. Because all evapotranspiration has not ceased this year, we will continue to take measurements until snow falls.

We continued our injections of aspen clones with both dye and sodium arsenite to determine the extensiveness of clonal root connections on the wide variety of sites where aspen occurs on the experimental area. To date, we have injected 109 trees in 41 clones and have found a total of 715 connected trees. The average root connections per clonal injection has been 7.6 for eosine bluish dye and 6.5 for sodium arsenite. Analyses of site factors promise to provide information that will enable us to treat aspen clones on specific sites when we get into extensive eradication studies.

Concerning the latter subject, we have laid out a battery of nine plots in a 3 by 3 Latin-square design in a large aspen clone on the experimental area, and the aspen trees are being treated in three ways. Three plots are clearcut of all aspen stems, three are clearcut and the stumps sprayed with sodium arsenite, and the aspen stems on the remaining three plots have been injected (by Little Tree Injector) with sodium arsenite and then left standing. All plots have been trenched completely around to sever all root connections between plots. Neutron

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1/ Croft, A. R., and L. V. Monninger. 1953. Evapotranspiration and other water losses on some aspen forest types in relation to water available for stream flow. Trans. Amer. Geophys. Union 34(4): 563-574.

2/ Snow evaporation studies are patterned after those conducted by Boyd Hutchison of the Rocky Mountain Forest & Range Expt. Sta.

access tubes will be installed on each plot and in the surrounding undisturbed stand; we shall then obtain subsequent measurements of soil moisture depletion under complete cover as well as under the sprout aspen stands that develop.

Our measure of the effectiveness of the eradication treatment will be a count of the numbers of sprouts that arise following each type of treatment. Clearcutting with no poisoning will serve as the control, inasmuch as we expect the greatest amount of sprouting to take place on plots treated in that manner.

A start on the evaluation of the effects of contour trenching on streamflow will be delayed until next year, because arrangements to have Halfway Creek watershed trenched (as reported in the last Semi-annual report) did not materialize in time for the job to be done this summer.

Great Basin Experimental Area

When Ronald Tew joined the staff of this project, it permitted us to launch full scale upon a program of determining the water requirements of important vegetation types in the Great Basin drainage. Ron has spent the summer installing more than 100 neutron meter access tubes at the Great Basin experimental area. His work will involve the determination of relative consumption of water by quaking aspen, Gambel oak, snowberry, gooseberry, bluebell, and other main plant types occurring in that area. The plot installations in aspen and oakbrush are designed to investigate the effects of aspect, elevation, and age class on water use.

For aspen, Ron selected three clones at each of two elevations, approximately 1,500 feet apart, vertically. At each elevation the three clones were chosen so that each had a different exposure. Within each clone, two perpendicular trenches were dug to sever the roots of connected stems. Of the four plots thus formed, two diagonally opposite plots were clearcut of all stems. The sprout stands that will arise this coming year will provide a juvenile age class to compare with the residual mature stand. Two access tubes were then installed on each of the four subplots, and measurements made over the next several years should yield a fairly good indication of water use by aspen of two different age classes, at two different elevations, and on three different aspects. Ron has also installed thermisters in the soil at various depths on these plots, and he will obtain soil temperature data to relate to evapotranspiration from the plots. Plots in the oakbrush type were laid out in the same manner as the aspen plots.

Soil sampling in rocky or stony soils can be pretty frustrating, but Ron says you've run into nothing until you try to drill holes for access tubing in stony and clay soils derived from limestone.

John D. Schultz

LAKE STATES FOREST EXPERIMENT STATION

Cadillac, Michigan

Geophysical Studies of Glacial Drift Aquifers

Fieldwork was completed during the past summer for a cooperative study with the Geology Department of Michigan State University. This project is utilizing two geophysical exploration techniques to describe the water-table depths and aquifer thickness in the upland morainal portion of the Udell Experimental Forest. The major emphasis has been placed on the use of seismic refraction methods, since an adequate velocity contrast exists between saturated and unsaturated sediments to make the water table an excellent refracting surface. It is too early to say with what degree of accuracy the water-table depth can be determined, as the computer runs have just started. Two rather surprising phenomena were:

1. The velocity through unsaturated sands remained constant at about 1200 fps. at depths below 10 feet. This indicates a constant packing of the sand particles, which is relatively unchanged despite an overburden of more than 100 feet in many cases.

2. The thickness of the sand aquifers is evidently much greater than we had expected. If the underlying slowly permeable layers are clays with velocities near those measured in surface clay layers (+3000 fps.), large portions of the Udell ground-water basins have aquifer thicknesses of 100 feet or more. If this is borne out in the final analysis, we will be able to apply many of the theoretical techniques which assume infinite aquifer thickness or a uniform permeability to the level of the drain.

Electrical resistivity measurements were taken along the same transects as the seismic profiles. Some characteristic resistivities for the major geologic conditions were obtained from well logging measurements in uncased drill holes filled with driller's mud. The method was handicapped by the low resistivity contrast between saturated and unsaturated sands and the extremely high resistivity of the surface layers in the outwash plain sands. Despite these problems, the preliminary analysis shows a good possibility for analysis by integrating methods such as Moore's method and the Barnes Layer Method. Sufficient resistivity contrasts exist in several profiles to utilize the theoretical curve matching technique. By utilizing existing well control, the seismic measurements and the reisitivity measurements will permit more detailing of overburden characteristic than would be possible with either method alone.

Ground Water Hydrology

A first approximation of the drainage basins under the Udell Experimental Forest was possible from six new wells in the upland section in the heart of the area (fig. 1). The generality that the water table is a "subdued replica" of surface topography is only true in part. As illustrated by the two profiles, the most striking feature is a drop of over 90 feet in the ground-water level over a 1/2-mile distance beneath the west ridge (fig. 2). The existence of a high ground-water dome beneath a basin in the center of the morainal mass suggests that this area is underlain by a mass of slowly permeable glacial till material. Six wells installed on the higher ridges showed the overburden in these areas to be predominantly sand. Data from the geophysical studies will aid in detailing the water-table contours between the widely spaced wells and will indicate the geological conditions at greater depths.

New Studies

A study of vegetative bank stabilization.--This study is designed to test various combinations of waterline and upper-bank treatments. Waterline treatment tested will include (1) rock riprap, (2) planting brush species, and (3) no treatment. Upper-bank treatment will include seeding and fertilizing plus various chemical mulch applications. Mulch materials tested include an asphalt emulsion, Esso Encap, Soilset, Terra Seal, and two Dow Latex products.

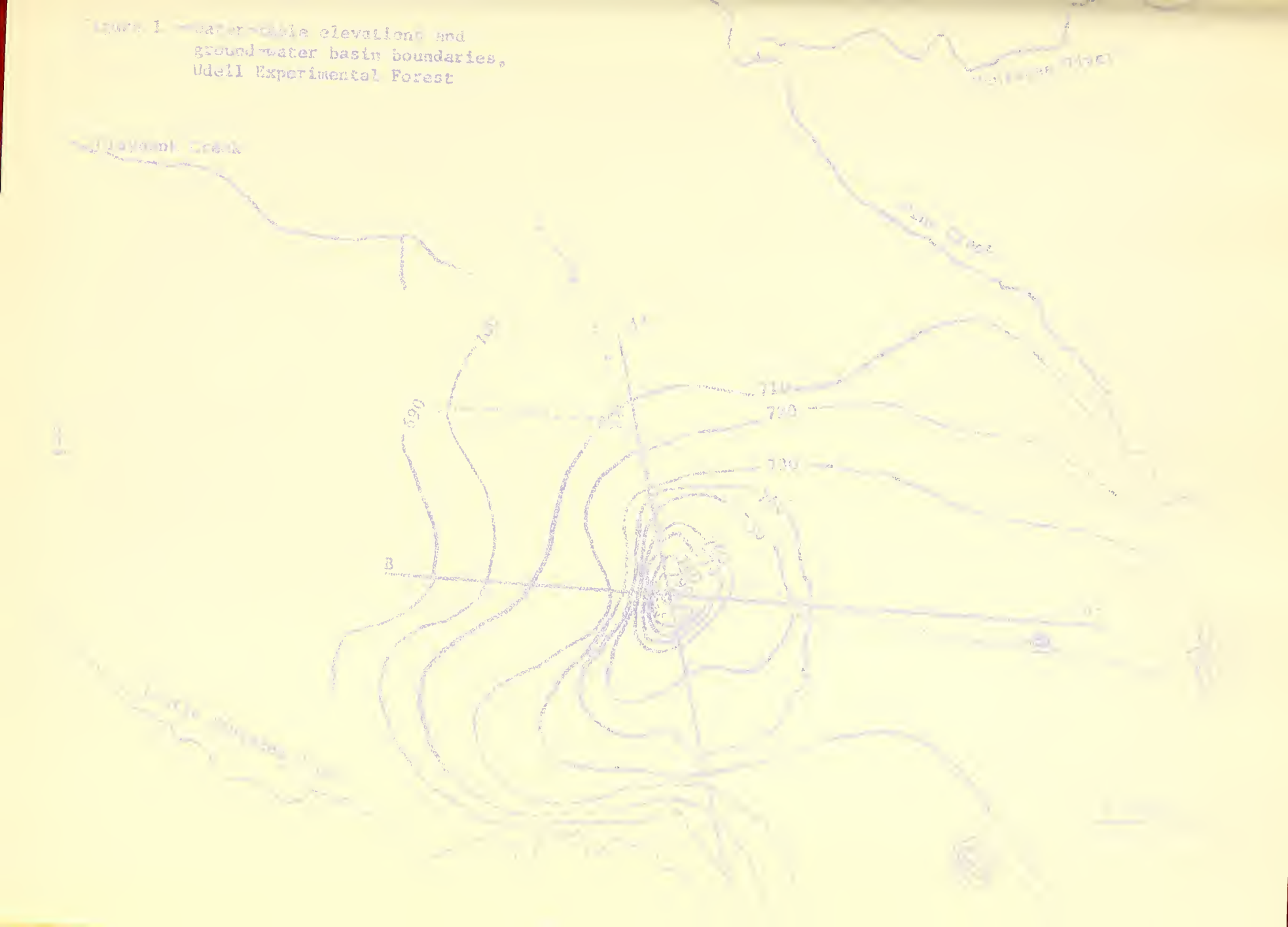
Initial results from the few banks already treated suggest that all the mulch materials tested are effective in holding the soil and encouraging germination.

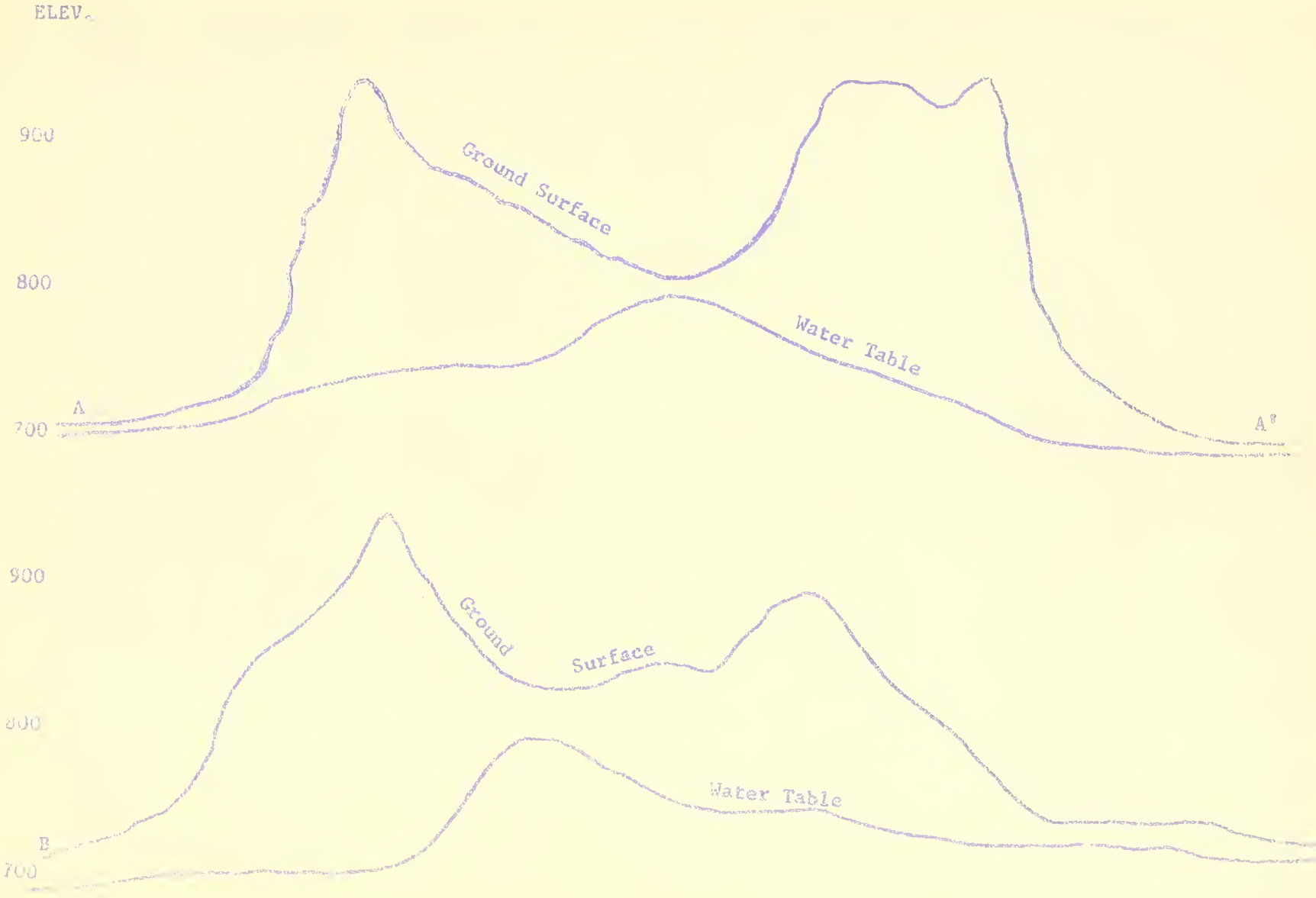
Ground-water budgets in shallow drift aquifers as influenced by cover type and water-table depth.--Well records for 2 water years will be analyzed to determine the evapotranspiration and the net ground-water yields from six shallow water-table areas on the Udell Experimental Forest. Water-table fluctuations will be divided into recession due to seepage flow, recession due to evapotranspiration, and recharge from rain and melting snow. Three of the areas have seasonally high ground-water levels which allow direct withdrawals from the aquifer by ET. The other three areas, in comparable cover type, have no direct ET discharge. Comparisons will be made between pine plantations and deciduous forests. Estimates of the water yield from selected subbasins in the Udell area will be attempted by weighting the separate cover-type and water-table depth budgets according to the area in each category.

- Dave Striffler

- Dean Urie

Figure 1.—Water-table elevations and groundwater basin boundaries, Udell Experimental Forest




ELEV.
900
800
700
A
A'
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Water Table
900
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B
Ground Surface
Water Table

CS-4

Grand Rapids, Minnesota

Facilities

APW funds have provided us with new and needed facilities on the Marcell Experimental Forest. A small field laboratory-headquarters building and a garage unit are now completed. This gives us an office, sleeping quarters, and limited lab space right on theForest. Some much-needed signs were also provided. In addition, APW funds were also used for fabricating the bottomless water control plots that are described below. Although administration of the program took some of our time, we did get useful facilities, so we feel we're ahead.

Bog Well Correlations

Each of our bog watersheds has a recording bog well and a network of up to 12 nonrecording wells. The nonrecording wells have been measured every few weeks in previous years. However, now, with a little data under our belt, we've worked out the prediction equation and correlation between each nonrecording well and the recording well in each bog. Most have fairly good 'r' values--around .98 and .99.

With these prediction equations, we now measure our nonrecording wells less often and depend upon our recorder to give us an accurate record of the water table throughout the entire bog. This speeds up our fieldwork and accumulates fewer records.

Preventing Icing in 'H' Flumes

As everyone knows, preventing a freezeup in low-flowing, metal flumes, as compared to V-notch weirs, is a real problem. We have several 2-foot type 'H' flumes with 10-foot-long approach sections made of sheetmetal. In late fall and very early spring before active snowmelt, low flows are common and ice buildup can cause interesting, but not accurate, hydrographs. Covering the structure and banking soil around the sides for insulation do not prevent freezing. Neither did a portable gas light.

Last spring, however, we made use of a small, infrared propane heater that really helped our problem. It's a small heater-cooker unit called "Camp-Champ" that is used by ice fishermen in our north country to keep fishing holes open. The heater weighs about 3 pounds, has a 7-inch-diameter reflector, and supposedly puts out 3,500 B.T.U. It costs about $19. Normally, the gas supply is a small propane cylinder (torch-size), but we've adapted it to run from a 100-pound tank of propane.

We cover our flumes and approaches, bank soil on the sides, and then mount the heaters inside the approach section with heat directed toward the float-well and throat. We didn't lose any records last spring due to icing.

Total cost for heater, high-pressure hose and adaption to a larger gas source was approximately $25 to $30. A 100-pound tank of propane lasted us about 5 weeks. If anyone would like more details we'll be happy to oblige.

More on Bottomless Tanks

In the previous Semiannual Report, we indicated plans to develop, install, and test the use of bottomless tanks as field water-control plots in organic soils with the water table near the surface. We indicated that we felt there would be little water movement into or out from the plot because of the low hydraulic conductivity of peats.

These water control plots are constructed by driving a galvanized cylinder, 3 feet high and 10 feet in diameter, into the organic soil profile such that the bottom edge is driven into the horizon of peats with low hydraulic conductivity.

Four cylinders have now been installed--two in an open nonforested bog and two in a small forested bog. Our observations and preliminary data again illustrate the low hydraulic conductivities of the peats.

Shortly after installation, water was pumped into the plots, creating a head difference of about 6 inches. This head difference maintained itself for a period of 8 weeks (July 15 - Sept. 6). Although the water table did drop in the water-control plots during drying periods, this was no greater and often less than that occurring in the bog itself. Thus, it appears that the water-table reduction in the plots is due primarily to water loss by evapotranspiration. Losses due to seepage are considered to be quite small, since no losses occurred when one plot was covered.

Assuming this to be true, rates of water loss for two different drying periods were calculated and are shown below:

Rate of water loss
(Inches per day)

Drying period	Water control plots		Forested bog (well records)	Evaporation pan (class A)		Potential ET (Thornthwaite)
	Forested	Open		Forested	Open	
7/31 - 8/8	0.132	0.216	0.132	--	0.204	0.144
9/6 - 9/11	.050	.101	.053	0.028	.075	.114

The drying periods above represent periods of clear skies and no precipitation. Average temperatures were 63.5° F. and 61.0° F., respectively. Potential ET was calculated using the Thornthwaite method. During the earlier drying period, water tables were quite high in the plots, because water had been pumped in to create a head difference. Thus, there was considerable free water surface resulting in high water loss from the open plot.

A nearby recording well provided a measure of water loss from the entire bog by drainage as well as ET. The figures given in the table above have been corrected for drainage based on specific yield of the peat and measured outflow at the outlet.

Class A evaporation pans were installed in both the open and forested areas. The pan in the forested area is below the overstory and less evaporation results.

From these early results, we are confident that the water control plots can be used to accurately measure evapotranspiration losses. A study is presently being designed to measure these losses from several vegetative communities and treatments for the entire 1964 growing season. Water control plots are being installed this fall.

- Roger R. Bay

- Don H. Boelter

La Crosse, Wisconsin

Gully Survey

We have spoken before of the woodland gully in southwestern Wisconsin. This unique feature is a byproduct of ridgetop farming. We knew that they were a common sight on the landscape; and that many of them were big. But we didn't appreciate how common and how big they are until we made a systematic survey on the Coulee Experimental Forest last spring.

Gullies 35 feet wide at the top and 15 feet deep are commonplace. Although most of them follow natural drainageways, here and there one is found angling across the slope, perhaps following an old cowpath or farm trail. These across-the-slope ditches (as they are locally known) also reveal how deep the soil mantle can be on the loess-covered hillsides--in places 15 feet, with bedrock still not in sight.

Moisture Movement in Frozen Soil

This is an area of deep frost penetration--commonly 3 feet or more. Thus, ground freezing is an important factor in winter and springtime hydrology. A couple of winters ago we ran a little study with the neutron meter to find out more about soil moisture migration with soil freezing. This has always interested us. A number of investigators have reported that moisture moves upward to the freezing front, and this accounts for the high moisture content of frozen soil. The data on this apparent phenomenon have never been too convincing, however.

We felt that the neutron method should show moisture movement more clearly. So we took weekly measurements in three tubes, around which we measured frost depth. Frost penetrated to a maximum depth of 38 inches on one plot, and to only 3 inches on another, which we had insulated with a covering of hay.

We found that:

1. Moisture content of the frozen soil did not reach particularly high levels during the freezing period (41 Pv maximum).

2. Water infiltrated and percolated through more than 3 feet of hard-frozen ground.

3. Moisture content of the frozen profiles changed frequently as a result of water movement into and out of the profile.

4. Water was released from the snowpack into frozen soil with only brief rises of temperature above the melting point.

5. Soil moisture increases in the frozen zone resulted from infiltration and percolation rather than from movement of moisture upward from unfrozen soil.

Incidentally, Bill Krumbach of the Southern Station found most of these same things in his Ph. D. study at Michigan State University.

Influence of Planted Conifers on Soil Freezing and Runoff

We recently had a study plan approved for this. We will plant three species (white pine, Norway spruce, and European larch) and study frost and runoff over the years of plantation establishment and growth.

Runoff will be measured from 13x26-foot plots. We have put in an experimental installation for testing this winter. The collecting trough is of redwood except for a sheetmetal bottom. We are using nonmetallic materials because of the heat-exchange factor. Plastic hose from the trough empties into a galvanized steel washtub to which is connected a standard domestic water meter. Tub and meter are housed in a redwood box, the top of which is flush with the ground surface. A single-flame gas burner will heat the unit to keep it from freezing up during runoff periods.

Runoff plot borders are 10-inch by 6-foot plastic strips. (We can get rejects for free from a local company.)

We will also compare several methods of measuring frost depth this winter: soil tube, resistance blocks, thermistors, and Soil Test's Frostmeter (a series of liquid-filled vials).

Trail Scooter Proves Out

With one field season practically behind us we can make a very enthusiastic report on the "Tote Gote" scooter as a watershed management research aid. It saves us a tremendous amount of time and travel. Some of our surface runoff flumes and our standard rain gages can be checked without even dismounting. We have had a few minor malfunctions, but nothing that we ourselves couldn't fix.

We recommend one to any unit that has to do a lot of foot or Jeep travel on routine gage runs.

Subsurface Hydrology

In the April-Sept. 1959 Semiannual Report, we mentioned the two types of springs found in the Driftless Area--one type emerges in runoff channels and the other type comes out of sidehills or ridges. The question concerning ground-water conditions then asked was, "Where is a watershed?" The April-Sept. report for 1961 repeated this question and outlined what we must do to delineate watershed boundaries. Well drilling for mapping the water table got underway during the summer of 1962 and was continued during the 1963 season.

To date 29 wells ranging in depth from 20 to 100 feet have been completed above one of the sidehill springs (S-9). From the very limited data analysis that has been made so far, it appears that ground-water highs coincide with topographic lows and ground-water lows with topographic highs (fig. 3). Then runoff channels represent watershed boundaries? We're not sure. For instance, we don't know whether water moves over bedrock from ridges and helps recharge or maintain the water mounds under the valleys.

The general pattern of ground-water fluctuations follows that of springflow, with some exceptions. All wells do not show recharge or discharge simultaneously.

Four wells above an "upper" spring have been completed. Water levels are quite stable, coinciding with the practically constant year-round discharges from these springs.

We are now using a water level sensor in conjunction with a standard water level recorder to record changes in ground-water level in a 1-inch-diameter well. The sensor is transistorized, and when the sensor bob is at the water surface the circuits are balanced. Any change in the water level results in unbalanced circuits and a small motor acts to raise or lower the bob. The bob wire passes over a recorder float wheel into the well, and changes in water level are recorded. Cost of the units is $195. More information can be obtained from W. G. Keck and Associates, Inc., Box 107, East Lansing, Michigan.

- Richard S. Sartz

- Willie R. Curtis

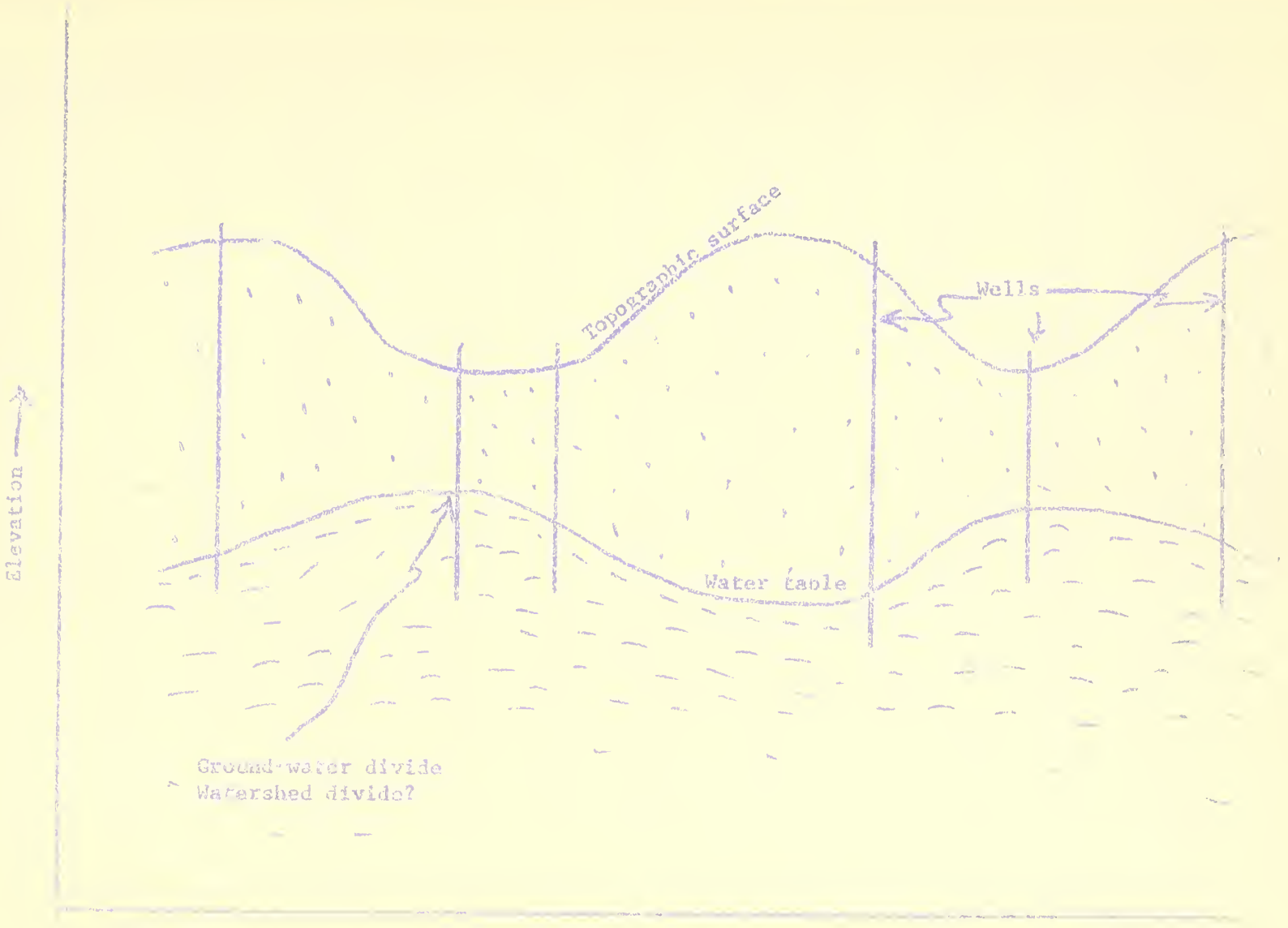

Figure 1.—Schematic of relationship of topography to water table above a ridge.

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NORTHEASTERN FOREST EXPERIMENT STATION

Division of Watershed Management Research

Semi-annual Report October 1963

GENERAL

A Northeastern contingent of Irv Reigner, Ken Reinhart, Jim Hornbeck, Howard Lull, Art Eschner, Don Satterlund (Syracuse), and Dave Mader (Univ. of Mass.) spent July 8-10 at Coweeta, listening, with admiration, to the discourses of John Hewlett and company, and seeing how many good ways APW money can be spent. We had a fine visit. Also, during the past semester Lull visited all projects, calling the roll before Clark Holscher's 3-weeks inspection in August-September. Clark, too, visited all projects and exhibited great patience with our considerable capacity to see one side of any question--ours. One of our two manuscripts for Departmental bulletins (the one on weir construction) moved with all deliberate speed to Washington, the other, on solar radiation was revised and may yet reach the presses. The Hubbard Brook group moved into their new building and the Fernow fellows saw theirs get started. Ken Reinhart received a cash award for a bang-up job of writing the Fernow results (14 papers), and Irv Reigner, and wife June, spent 6 weeks in Europe seeing the sights including some watershed research.

FERNOW EXPERIMENTAL FOREST

Calibration analyses have been completed for Fernow Watersheds 6 and 7 and the decision made to treat these watersheds. For this analysis, we developed a revised procedure for determining adequacy of calibration: a procedure based on testing individual after-treatment values for significance (rather than using analysis of variance or some other method).

Originally, we planned to use Watersheds 6 and 7 (as a follow-up on the "package-deals" on Nos. 1 to 5) to separate timber-cutting effects from skidroad effects. We decided that this is not necessary; to a very large extent, in our experience, the increases in discharge are due to timber cutting and the damage to water quality is related to the skidroads.

So we have decided to make Nos. 6 and 7 into "benchmark watersheds". What will be the effect on streamflow, under local conditions, of complete vegetation removal? Logging (starting November 1, 1963) will be followed by poisoning of culls, poisoning of stumps, basal-spraying of small stems, and a follow-up foliage spray (in spring, 1964) to catch whatever is left. Later

treatments may also be necessary. We know we won't be able to kill that last leaf but we'll make a good try at it.

In an attempt to kill 2 birds, the watershed treatment will be by halves, upper and lower (with dividing line on the contour). In the first phase, Lower 6 and Upper 7 will be treated; the remaining halves will be treated 2 or 3 years later.

Jim Hornbeck has been busy taking calibration measurements of microclimate on Watersheds 6 and 7: Air temperature at standard and 6-inch heights, soil temperature at 2-, 4- and 8-inch depths, evaporation pan, and Bellani black-plate atmometer measurements.

Reinhart and Hornbeck visited Coweeta in July and Hibbert and Cunningham returned the call in August. At Coweeta, records of Fernow No. 4 are being compared with Coweeta streams. Some interesting things are showing up; for one thing, it appears that on the Fernow a much larger proportion of rainfall is included in the storm runoff. In neither area is overland flow involved, it is apparently a question of the rapidity of sub-surface flow.

--Ken Reinhart

HUBBARD BROOK EXPERIMENTAL FOREST

On-the-ground cooperative studies have been initiated with Dartmouth College at Hubbard Brook. Their interests lie in determining the inflow and outflow of minerals from an ecological system. Because of the tight bedrock restricting deep seepage, and the virtually unweathered bedrock surface upon which the glacial drift soil rests, the Hubbard Brook watersheds are ideal for such studies. We are presently cooperating with three professors (an ecologist, a limnologist, and a geologist) who are interested in the cycling of all elements in the watershed but initially concerned with calcium, magnesium, sodium, and potassium. Almost endless possibilities for study exist along these lines to help us gain more basic knowledge of our watersheds and their behavior--such as rates of weathering of bedrock and mineral and organic fractions of the soil; rates of surface organic layer accumulation; and phenological studies comparing occurrence of biological events, both plant and animal, with climate and streamflow.

A large portion of our time this summer was spent in developing our physical plant. Accelerated Public Works money enabled us to provide essential facilities for our new office-field assistants quarters and construct needed additional improvements, ready 3 new stream-gaging sites for construction, and start construction on one (this is number 7), and cut access trails and openings for a network of rain gages for three new watersheds. Also completed this summer were 2 miles of access

road to the three stream-gaging sites.

Stream-gaging Station #7 (to be completed this fall) will be a combined sharp-crested 1.25-foot 120° V-notch with a 4-foot San Dimas flume. This is designed to handle flows up to 235 cfs. on the 190-acre watershed. Identical structures are planned for 2 adjacent watersheds of 160 and 175 acres.

The educational leave bug is contagious. George Hart had hardly unpacked his bags after returning from graduate study at the University of Michigan when Ray Leonard departed for the ivory tower routine at Yale. Ray will specialize in microclimatology under Bill Reifsnyder.

--Bob Pierce

NEW LISBON

New Lisbon had both good and bad fortunes during the last half year. April was the bad month. First, Karl Nicholas suffered two broken vertebrae from lifting a bag of Sacrete. Then a wildfire burned over about half of the Lebanon State Forest, on which we are located, so we may be somewhat restricted for future study areas. The good fortune for Irv Reigner is his 6-week trip to Denmark, France, and Great Britain.

Newark Watersheds

Tabulations of precipitation are now up to date and show that the ridge station has been receiving consistently less rainfall than the stations at lower elevations. The ridge station is actually not on the ridge top, but on a 40-percent slope within the gaged watershed. To determine if the catch of this station is a representative sample of rainfall in the area or is affected by wind, two other gages have been installed: one equipped with an Alter windshield, and the other tilted perpendicular to the slope.

Another one of the concrete weirs has begun to leak. Watershed #2, which has the strongest sustained flow of the three watersheds, went dry this summer for the first time. With no flow over the notch, a leak in the front wall became visible. An attempt to patch the leak with asphalt and vinyl plastic sheeting was unsuccessful because enough water seeped into the weir to prevent the concrete from becoming entirely dry. A complete vinyl lining will be installed.

Baltimore Watersheds

For some time it has become increasingly evident that Watershed #3 was not yielding a reasonable streamflow through the weir. The tiny watershed, only 21.6 acres, has never been

dry in the summer but the winter flows are unreasonably low--not very much higher than the summer flows. A suspicion that part of the yield is leaving through underground geologic structures was tentatively confirmed by several visitors from the groundwater branch of the U.S. Geological Survey in June. We are now attempting to have a geological survey made of the watershed area.

Penn State Watersheds

The installation of access tubes for a neutron probe has hit a snag--or rocks. Bill Sopper has been able to place tubes on the Shale Hills Watersheds, but the sandstone rocks and cobbles on the Leading Ridge Watersheds have been too much for hand augers. On order now is a portable 2-1/2 HP power drill from Forestry Suppliers. This will afford a worthy comparison to the "Little Beaver" power auger which was described by the Central States' report in March 1962.

Field work for the water contamination study is now complete. The streamside reaches that were sprayed last summer were recently examined for effectiveness of kill. The results were surprisingly good, and in the Newark area at least the emulsifiable acid showed about as good results as the more common ester of 2,4,5-T. The emulsifiable acid, which causes less contamination than the ester, was not expected to provide as good a kill.

General

Some rather ancient interception data from the Poconos was analyzed in preparation for publication. The first step was an evaluation of the trough gages used to measure rainfall and throughfall. It was found that the trough gages did not measure total rainfall accurately, that some of it splashed out of the troughs. An interesting analysis showed that this loss decreased as the slope of the trough increased. When the slope reached 25 percent, the loss became zero, indicating that the raindrops no longer bounced out, but were deflected into the trough. The older California studies, which recommended trough gages highly, were conducted on slopes of 30 to 40 percent, thus substantiating the above interpretation.

A comparison was made of monthly soil moisture changes as measured at Dilldown with estimates from the Thornthwaite method (daily basis). They were very similar, so close that we are now more confident of the accuracy of the measured values. Thus, the Thornthwaite method produces two estimates of the water balance cycle that seem to be quite accurate--actual evapotranspiration and soil moisture change.

Thornthwaite's method of estimating available gravitational water would not be useful in estimating runoff for a watershed having true groundwater such as the Dilldown Watershed. But for those watersheds having little or no groundwater storage, Thornthwaite's estimate of runoff might be an extremely useful statistic to use in single watershed calibration. In a monthly analysis, for example, the estimated runoff (based on climatic data) could be used as an independent variable in a simple regression with measured runoff as the dependent variable. The regression developed during the calibration period could then be used to detect treatment changes.

Looking toward our proposed study of heat and energy relations, we again examined our ancient, obsolete anemometers. Tests some years ago indicated that no two instruments gave comparable results when exposed side by side. Overhauling according to instructions had little effect. Then we noticed that the bottom of the spindle shaft, which rests on the bottom bearing plate, had become flattened on the slower instruments. A little grinding and polishing of the spindle shaft, to again make it round instead of flat, has made a world of difference in these anemometers.

Trying to find an inexpensive method to measure the pH of streams, we investigated Hydrion papers. These papers can be obtained in many ranges of pH and are commonly used in industry and medicine. However, while they worked in some ranges of water pH, they were not sensitive in all ranges. Some correspondence with the manufacturer confirmed our suspicion that the stream waters are too lightly buffered to react with the papers. It appears that we should obtain a Helige Comparator, unless someone has a better idea.

--Irv Reigner

SYRACUSE

Most of the past six months has been spent in field work, or preparing for field work. We made a fairly extensive ecological survey of the 491 square mile Sacandaga watershed to define vegetation changes occurring over the 50 years for which a streamflow record is available. In selected stands the present stocking and past growth and mortality were determined, as well as estimates of crown cover by evergreen species and the deciduous group. Crown depth information and soil descriptions were also taken in the stands studied. Summaries of these data, and other historical records, will be used in an attempt at explaining the large decrease in dormant season streamflow and the smaller decrease in growing season streamflow mentioned in previous semi-annual reports.

Two joint papers were given at meetings during the past half year--Don Satterlund gave one on Land Use, Snow and Streamflow Regimen in Central New York at the A.G.U. meeting in April in Washington, and Art Eschner gave one at a Forest Land Use Conference in Albany in September on Forest Land Use Problems as Seen by the Water User.

--Art Eschner

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A forest atlas of the Northeast. Howard W. Lull.

PACIFIC NORTHWEST FOREST AND RANGE
EXPERIMENT STATION

Semiannual Report
Watershed Management Research

April 1 - September 30, 1963

PROJECT 1601--Water Yield and Erosion

Forest Hydrology Laboratory - Wenatchee, Washington

The move in late July into our new lab removed a number of serious obstacles to the orderly accomplishment of research--and presented a few new obstacles. Our new building is designed particularly with the use of radioisotopes in mind. We are ready to proceed with our first study using Fe^{59} to trace rates and patterns of soil particle movement on eroding slopes.

An isotope storing room is available for dilutions of hot solutions. This room is large enough to use as a hot lab for studies of limited scope. The soil chemistry and physics labs both have isotope fume hoods. Our counting room is on a separate air-conditioning system and now contains an almost-operating single-channel gamma scintillation counting system. We also have a D. U. spectrophotometer installed with the flame unit on order.

By the time semiannual report writing rolls around again, we shall have a much better idea concerning the good and poor features of our building. We also hope to have more hot studies going.

New Study Approved

W-18. A preliminary study of soil erosion using radioisotopes.

Objective: To answer the following questions.

1. What is the rate and pattern of soil particle movement on apparently eroding sites of basalt, granodiorite, and sandstone soil parent materials?

2. Is soil erosion best measured by a spot or line application of a radioisotope?

3. How is radioactive $iron^{59}$ retained in the soil when added as a ferric iron?

--David D. Wooldridge

AEC Radioisotope Course

From April 22 - May 17, 1963, I attended the 89th session of the basic radioisotope course given by the Special Training Division of the Oak Ridge Institute of Nuclear Studies (ORINS) at Oak Ridge, Tennessee. The following description of the course is presented in the hope that it may be of interest to other research workers.

Twenty-six participants attended the session, including 7 from private industry, 9 from universities, 8 from government laboratories, and 2 from hospitals. The 4-week course consisted of lectures, laboratory experiments, tours, and special topic seminars. About half of each day was devoted to lecture, the other half to laboratory work. Topics covered during the first week were radiation units, nature and interaction of charged particles, interaction of radiation with matter, characteristics of beta particles, scintillation counting, gamma-ray spectrometry, survey instruments, and licensing and regulations. The second week was mostly devoted to a study of radiochemical techniques used in the laboratory such as carbon-14 assay, standardization of radioactive sources and solutions, and isotope dilution and isotope exchange techniques. During the third week, topics included spectrum analysis, multichannel analyzers, activation analysis, fast neutron activation, gas chromotography, thin layer chromotography, autoradiography, biological effects of radiation, and radiation safety. During the fourth week, topics included dosimetry, nuclear chemistry, tritium labeling, selection of instruments, special aspects of scintillation counting, and relative sensitivities of detection. Some topics, such as radiation safety, liquid scintillation and gamma-ray spectrometry were presented several times in increasing detail during the 4-week period. During the course, some time was allowed for elective experiments and consultation with instructors about techniques of particular interest.

The pace, of course, especially during the first 2 weeks, was too fast to absorb everything presented in the lectures. Some material was repeated several times during the course, which helped considerably. During the last 2 weeks, the pace was much slower, and more time was available for informal discussions with the staff.

Throughout the course, considerable emphasis was placed on gamma-ray spectrometry, activation analysis, and use of multichannel analyzers. I felt that not enough attention was devoted to the ordinary type of labeling or tracer experiments which are so often used in biological research. However, the course did include a wide range of topics which allowed one to become acquainted with many different techniques and instruments.

Some aspects of the course deserve special mention. Ample time was allowed during the latter part of the course for elective experiments or even short projects conducted with the help of the staff. To take best advantage of this, participants should have definite ideas in

advance for extra experiments or projects. I thought that the portion of the course dealing with health physics and radiation safety was particularly good. Participants were required to conduct radioactive contamination surveys of the isotope laboratories, which provided useful practical experience. A valuable aspect of the course was the opportunity to discuss problems, techniques, and instruments with other members of the class. Many of them had considerable previous experience with isotopes, and many interesting discussions were held.

This course is, in general, an excellent one and is strongly recommended to others interested in using radioisotopes in their work.

--William Lopushinsky

Forest Meteorology Studies

The transfer of operations to the new hydrology laboratory was a welcome event, affording an opportunity to operate horizontally on the available bench space rather than vertically. Adequate electrical power rather than a single extension cord makes most aspects of the work easier, although the occasionally interesting shorted 110-volt line, blown fuse, sparks, and noise will be missed.

To comment further on some items mentioned in the prior semiannual report: The data acquisitive system has been given an operational test and performs satisfactorily. Some of the finer points such as circuit dress and cabling still need attention. Also, movement of the instrument shelter to the 6000-foot site has been accomplished. At times, with the trailer duals supported only by air pressure, some doubt was expressed by both the driver and myself as to the necessity of the journey.

The preliminary radiation survey of the Wenatchee drainage was run this past summer. Reduced data for inclusion here is not available; with eleven stations recording, a considerable amount of data still is to be analyzed.

Maintenance of this network provided some trouble not anticipated, necessitating more time than initially planned. Without the generous assistance of the NFA providing radio and phone contact with the sites, and the ability and willingness of my summer assistant, Gordon S. Gienty, this survey would not have been possible.

--W. B. Fowler

Soil Moisture Determinations

The neutron scattering method of determining soil moisture has become widely accepted as the most accurate method yet developed. This method has not produced satisfactory results for surface layers, however, due to neutron escape at the soil-air interface. The special surface probe does not work in natural environments because of surface irregularities and organic litter. Gravimetric methods disturb the site excessively if frequent sampling is required. Electric resistance units require calibration, which is time-consuming and also leads to site disturbance. A special calibration of the depth probe as first proposed by Sartz and Curtis offers some hope, but the method remains to be proven.

The purpose of this note is to suggest that for some purposes we really do not have to determine soil moisture near the surface. In many cases, our ultimate objective is to find out whether or not we can increase water yields by some management practice, and if so, by how much. I would like to advance the hypothesis that in much of the West (at least in the Pacific Coast States) the surface foot of soil has little, if any, potential to produce a change in water yield. In the area I'm referring to, the summers are warm and dry. It is my feeling that transpiration from any vegetal cover, in conjunction with evaporation, will completely utilize the retention storage capacity of the surface foot. If this is the case, all potential for change in water yield will be confined to the deeper soil layers, and we can determine the magnitude of any change by computing soil moisture deficits in the soil mantle below 1 foot.

Admittedly, this line of reasoning breaks down in the more humid regions, where substantial amounts of drying-season precipitation occur. Those of us in the Far West, however, may be able to dispense with surface soil sampling in some studies. I have begun to accumulate some data which may verify or disprove the above hypothesis, and I solicit comments from anyone whose experience or data are relevant.

--H. G. Herring

PROJECT 1602--Watershed Logging Methods and Streamflow

Small Watersheds - H. J. Andrews Experimental Watersheds

Watershed 3.--Recent slash burning of three logged units in watershed 3 completes the first phase of treatment. Roads were constructed in this watershed in 1959; three units totaling 25 percent

of the drainage area were clear cut in the fall of 1962; and these units were broadcast burned during the last week in September. We plan to follow trends on this watershed until it again stabilizes. In this area we can expect maximum change next year when a scattering of annuals appear on the burned areas. The second-year annuals will make up a good cover. In following years, perennials and woody species take over. In many clear-cut units it may be 8 to 10 years before Douglas-fir trees are again dominant on the site. Results to date on this watershed follow the general pattern of no evident increase in peak flows, about a 15 percent increase in low flows and a marked but irregular increase in sedimentation. To a large extent, any serious sedimentation is limited to the relatively short time during major rainstorms and immediately following soil disturbance.

Watershed 1.--Watershed 1, currently being logged by the Wyssen W-200 skyline crane, is about 50 percent felled. Approximately 1/4 of the area is logged with about 2-1/2 million of the 12 million on the area already on its way to the mill.

Watersheds 6, 7, and 8.--A year ago we installed a 2-1/2 foot H-flume built from plans supplied by our cohorts at LaCrosse. It worked so well, we are installing two more on small watersheds 35-85 acres in size. Conditions here are widely different from watersheds 1, 2, and 3. These have a uniform stand of young (125 yr.) Douglas-fir of approximately rotation age which grows on a gentle southerly aspect with deep soils. A good perennial flow comes from even the smallest of these drainages. These watersheds will be partial cut following recommendations of FMR. Tractor logging and intensive management will contrast with the extensive methods required on the much steeper watersheds 1, 2, and 3.

Small Watersheds - South Umpqua Experimental Forest

With a dash of APW funds, we are constructing two more 120° V-notch weirs on tributaries of Coyote Creek. These, added to the two existing weirs, will give us a chance for a cooperative study with FMR of management practices in the mixed conifer zone of the southern Oregon Cascades. It is a considerably drier area than the Andrews and Bull Run areas and probably approaches conditions in northern California. Streamflow in late summer drops to a bare trickle even on a 160-acre watershed. In spite of less streamflow and gentler slopes, these drainages produce more sediment.

Our watershed studies, now concentrated in four groups, are characteristic of areas representative of a variety of soils, geology, vegetation, climate, etc. Soil scientists here are using a concept of benchmark soils which represent a given set of characteristics chosen from a continuum. We are faced with much the same problem when it comes to watershed characteristics. Perhaps we should adopt the idea as benchmark watersheds.

ADP Progress

We're almost caught up on our hydrograph analysis, thanks to a recently developed ADP program. We've found this wealth of data isn't obtained without some difficulties. Since the machine calculations require sequential data, we must check and recheck to be sure the data punched are digestible by the 650. One number that upsets the sequence of dates or times causes the machine to come to a schreeching halt. A time-consuming search is required to find the stumbling block.

--Jack Rothacher

Water Chemistry

Due to the recent emphasis of the multiple-use concept, forest managers are asking for more sophisticated information than ever before on which to base decisions where there is a choice of management alternatives. Interest is sharpened where conflict between uses exist. Many aspects of burning have been investigated, but very little has been done to define the relationship between burning and water quality. Our watershed experiment at the H. J. Andrews Experimental Forest on the west slope of the Cascade Range offered an excellent opportunity to study this relationship. Five paired samples were taken from three adjacent watersheds throughout fall and winter storms. The Department of Health, Education, and Welfare, a cooperator in the study, performed analytical work. "Before" logging and burning relationships were defined for 1 year. These watersheds are in the old-growth Douglas-fir forest type. Stands carried 50-100 M bd. ft. per acre before logging.

"Before" treatment results show a high degree of correlation for individual elements in paired samples taken from adjacent watersheds. Therefore, the paired watershed technique will be used to estimate changes in 1) level of individual elements and 2) quantity of individual elements carried from the watershed during each storm. Slash in one quarter of the area in one experimental watershed, logged during the winter 1962-63, was recently burned. We think that results from the next storms will be most interesting.

--R. L. Fredriksen

New Study Approved

C-14. Detailed mapping and determination of physical, chemical, and hydrologic characteristics of soils in three small experimental watersheds.

Objective: This study is designed to answer the question, "What are the variations in soil properties over three contiguous small watersheds which may have an influence on water production and quality?"

To meet this objective, we have begun an inventory of the soils in the three small watersheds located in the H. J. Andrews Experimental Forest. As was pointed out in an earlier semiannual report, a soil survey conducted in 1962 indicated a complex soil pattern on the watersheds. Our work this summer has certainly borne this out. At this point we have remapped the soils in considerable detail and are now involved in making profile descriptions and the collection of soil samples.

The complexity of the soil pattern is not only due to the variety of rock types present, but also the many forces which have modified the bedrock since its deposition. It is true, however, that the list of parent materials we have encountered in this 600-acre area is fairly imposing: greenish breccias and tuffs, reddish breccias and tuffs, basalt, andesite colluvium, and a mixed fine-textured colluvium of doubtful origin. But the picture is further confused by the processes which have contributed to the deposition and alteration of these materials in this steep portion of the Cascade Range. Processes include alpine glaciation, mass downslope movement of mantle, and, in some cases, bedrock and rock weathering, either in place or after movement has occurred. All factors have combined to make the soil mantle a varied one, and as a result, we have had to map nine different soil series in this comparatively small area.

Soil profile development, as expected, is generally weak. A-horizons tend to be thin, and B-horizons either weakly developed or completely absent. We had also anticipated that depth to solid bedrock, especially in steep areas, would not be very great. In this, we were mistaken. Deep deposits of unconsolidated material have been found under the solum in so many cases that we are beginning to think this is the rule rather than the exception. It is especially unnerving to find such a deep unconsolidated deposit on steep, smooth slopes when one has already decided that the only soil possible is a shallow residual one on bedrock. In many cases, the underlying material appears to be colluvium which has moved downslope simply under the influence of gravity. Frequently, stone lines attest to several periods of deposition. We can't tell how much glacial activity has contributed to these mass movements of the past. Undoubtedly, some of the material has been glacially deposited, but perhaps this is restricted to the lower elevations.

Under some soils, the bedrock is weathered to a depth of 30 feet or more. The breccias apparently weather readily, and shallow soil profiles are often found developing on deep deposits of thoroughly rotten, cheesy rock material. This well-weathered breccia may have a clay or silty clay texture and therefore has a very considerable water-holding capacity.

We are not sure of the hydrologic significance of these thick layers of soil-like colluvial and residual materials. The deeper portions, at least, appear to remain very moist throughout the dry summers. They do, however, undoubtedly offer some space for detention storage. In addition, they may contribute greatly to summer streamflow by means of unsaturated moisture movement within the mantle. In the rainy season, much of the saturated, subsurface flow apparently occurs in these layers.

--C. T. Dyrness

SEMIANNUAL REPORT

Pacific Southwest Forest and Range Experiment Station

April through September 1963

WATER SOURCE HYDROLOGY

Watershed Equivalent Plane

R. E. Horton utilized data from topographic maps to compute an equivalent surface for watersheds, which theoretically would serve as an index of the solar radiation received on the watershed. The surface defines the general slope and aspect of the entire watershed. By applying trigonometric principles to net slope components, he obtained the equivalent slope and azimuth of the watershed surface. A 7090 computer program has been written to use Horton's method to determine slope and aspect of watershed equivalent plane.

A grid pattern was selected for each watershed such that a maximum of fourteen lines uniformly covered the entire watershed basin in N-S and E-W directions. The data recorded were the grid line lengths in inches and the elevations in feet at the points of intersection of the lines at the watershed boundary. U.S.G.S. topographic maps of 1:24000 and 1:62500 were preferred. Other necessary data included a scale conversion factor and watershed identification symbols.

From this information, three program subroutines determined (a) the slopes of the north-south and east-west components of the equivalent plane, (b) the slope of the equivalent plane, and (c) the direction (azimuth) of the plane.

For each watershed, a set of seven data cards were read and processed. A built-in error routine exists in the program to ensure that these cards are read in their proper sequence to avoid possible erroneous output. If a set of cards is detected to be out of sequence, the program is designed to print the error and its location within the data deck, clear all remaining cards for that watershed, and proceed to the computations for the next watershed included.

Jerry D. Lent

What's in a Name?

Water research everywhere and not a hydrologist in sight. I am in full agreement with Hewlett's comments (Semiannual Report, Apr. - Oct. 1962). As an extension to this discussion, I would like to make a concrete proposal that the Washington Office should push for the creation

of a Civil Service classification for "Hydrologists."

Other federal agencies are plagued by this same lack of identification for hydrology. Must reading for all watersheders is the Federal Council for Science and Technology's 1962 report, "Scientific Hydrology," from which the statistical information which follows was gleaned. The federal government employs about 65 percent of all scientific hydrologists in the U. S. but the "1959 survey of white collar workers in the federal government" (Civil Service Commission report) lists only five (count them on one hand) hydrologists.

With a "Hydrologist" classification, many of our specialists would still prefer to be considered research foresters, soil scientists, or geographers, and this is their right. However, many of us (including myself) would prefer to be called hydrologists.

How would such a classification improve upon our present system?

Recruitment: New blood is slow in identifying itself with hydrology. About 18 percent of all scientists are under 30 years of age--only 9 percent of the hydrologists are. Is there much incentive to study hydrology in the new graduate programs when you know that there is no job classification awaiting you upon graduation? If you are to meet Civil Service requirements in some other field, isn't it better to prepare yourself in the field for which you will be rated than to broaden your knowledge of the hydrologic system?

Employment: When a qualified hydrologist comes along, is it easy for us to hire him? A broadly trained hydro-scientist usually has fewer hours of credit in his specialty field than someone following a traditional sequence in the specialty. Thus he often has a lower score on his CSC rating. Many of our prospective employees are misfits in the classification scheme as it now exists. How often are your hydrologists hired on TAPER appointments until they are picked up on selective certification? Is this good for morale?

When I first broached this subject with the W. O. inspectors in March, 1962, one objection was raised. How do you define a hydrologist? A hydrologist is a person thoroughly trained in one of the pertinent basic or applied sciences who has learned to apply his specialty to the hydrologic system (which requires a combination of principles and methods and a certain body of knowledge unique to hydrology) and who has an interest in and at least an elementary knowledge of each of the component parts of the hydrologic system. A CSC examination could be structured around the above definition of a hydrologist. Options could denote hydrologists (Land use) or (Ground water) etc., if it is necessary, but all hydrologists should uniformly have a general knowledge of the component parts of hydrologic systems.

I feel that the Forest Service should join with other agencies in requesting the Civil Service Commission to create a Hydrologist classification--one that will stand on its own feet as a discipline and not be a descriptive modifier to some other specialty. This would allow us to say to future colleagues, "Yes, train yourself as a hydrologist and we will be able to hire you as one--no matter where your roots lie."

If you agree or disagree with these thoughts, let the W. O. know.

Kenneth L. Bowden

SNOW ZONE MANAGEMENT

General Comments

The storm of January 1963 which dumped 16-17 inches of rain on 4-12 inches of snow water equivalent in the high Sierra caused partial to complete destruction of all but one out of thirteen gaging stations. Damage ranged from total destruction of one flume to fill-up with debris of all but two stilling basins. Much of this summer's efforts of several staff members has been devoted to repair and sediment clean-out of these units.

Clark Gleason has just received an outstanding performance cash award for organizing and directing the Teakettle Experimental Forest cleanup following this storm. This job was completed at a large money saving to the Station in the face of an almost impossible fiscal deadline.

We have received word that U.S.G.S. is purchasing 5,000 Fisher Porter stream gages on a lease-purchase deal for its regional units. This should result in a large number of the current stream gages going on surplus. Perhaps the Washington Office might look into the possibility of picking up a group of these if there is enough interest.

Dave Miller's very complete review of the world literature about interception will be published in installments as chapters. This rather lengthy review should provide an excellent beginning point for much of our future research about this phenomenon.

James L. Smith
Project Leader

A.E.C. Contract

The Snow Project is again the recipient of an AEC grant to study the use of gamma and neutron probes for measuring snow density and melt.

Additional research is planned on the effects of snow-soil and snow-air boundaries and on methods of minimizing these effects. Suggestions from probe users as to promising techniques to employ in the study will be appreciated.

Donald W. Willen

Plastic Zero Water Level Instrument

A simple, direct-reading instrument has been designed and used effectively to zero water level recorders used with V-notch weirs in the Sierra Nevada of California. As stream-gagers know, discrepancies are often found between the staff, tape, and pen readings, raising the question: Which is correct? The new instrument gives a quick and positive answer by measuring the water level of the pond above the V-bottom.

The instrument consists of a sheet of clear plastic cut to fit the V-notch, with a piece of engineer's tape mounted so as to bisect the V-notch angle. The plastic is held vertically in the V-notch for a moment, so as to block the flow, and the pond level is read on the tape. The tape can be read with accuracy to 0.001 feet under good light conditions, and to 0.002 or 0.003 feet in poor light. The instrument can be used with ease by one person at stages up to about 0.7 feet. Specifications are available on request.

Clark H. Gleason

Forest Openings and Snow

What portion of the increased snow found in openings is a true increase rather than mere redistribution of the total snow supply? Data from 58 to 66 snow courses provide some answers. We can compare the average of snow courses within forests with snow courses having openings as part of the site:

	Snow at maximum pack	
	1958	1959
	---(inches water)---	
Snow courses:		
In forest near opening (area 1 1/2 times area of opening)	56.0	22.6
In opening (average all sizes)	63.2	26.3
Within forests, 35 percent density	57.0	23.2

	Snow at maximum pack	
	1958	1959
	---(Inches water)---	
Snow courses:		
Within forests, 50 percent density	53.4	21.5
Within forests, 90 percent density	48.1	15.8
Opening-associated snow (opening plus extra snow surrounding)	67.1	29.0

Only about half the difference between forest and cut opening (that is, 67.1 - 53.4 = 13.7) was found when comparing openings and adjacent forest (63.2 - 56.0 = 7.2). This is contrary to some interpretations that openings exaggerate the difference between cut and uncut areas. Thus, the effects of openings on snow were not fully indicated by differences in snow within and adjacent to openings.

The effects of management in drought years may be interpreted from the above data. Cutting openings increased snow storage by 35 percent in the drought year of 1959 as contrasted with 26 percent in the near maximum year of 1958 (both compared to a 50 percent forest). In contrast, if by selection cutting we reduced a 90 percent dense forest to one of 35 percent density, we would get nearly as great an effect in the drought year--34 percent increase--but only a 17 percent increase in the year 1958. The effectiveness of selection cut in drought years applies only to the spring snowmelt runoff; soil moisture deficits would deplete total yield. In years of heavy runoff, the snowmelt flood runoff is considerably reduced so that where forest control of flood runoff is required, selective cutting promises less snowmelt floods than does strip cutting.

For how many years does the excess of snow in cut strips persist? We have measured snow accumulation in a strip made by a powerline clearing made 10 years ago and also in an area of that clearing widened 5 years ago. The excess of snow in a 5-year-old cut area was the same as that expected the first year after the cut--13 inches; the excess in the 10-year-old cut area, where the red fir reproduction is 7 feet tall, was still 10 inches. You will recall that in the Fraser study in Colorado, remeasurement of the cuttings 13 years after the logging showed no apparent decrease in the excess of snow in the cuttings.

Henry W. Anderson

Yuba Pass Test Results

The recent test included a simulation of a wall-and-step cutting and strip cuts. The tests also included variation in residual stand

treatment and slash disposal. Five east-west strips (0.6 miles long, 135 feet wide, 400 feet apart) were cut in the fall of 1962 in an old growth red fir stand in the Tahoe National Forest near Yuba Pass, California. First results were from measurements of the snowpack at some 400 points at about the time of the maximum pack, April 24, 1963, and again on May 21 when about 60 percent of the pack had melted. Snow in the center of uncut forests averaged 19 inches on April 24 and 7.7 inches on May 21, 1963. Excesses of snow water equivalent (compared with uncut forests) associated with cutting were:

Date and area considered	Excess of snow associated with treatment				
	Slash piled	Slash lopped	Small trees left	Slash dozed downhill	Wall-and-step 1/
	(Inches)				
April 24, 1963					
Cut strip, only	4.4	6.4	8.0	14.4	18.9
Whole forest	1.1	1.6	2.0	3.6	4.7
May 21, 1963					
Cut strip, only	7.2	7.2	-5.2	-1.2	13.2
Whole forest	1.8	1.8	-1.3	-0.3	3.3

1/ In wall-and-step cutting one-fourth of stand was clear cut with slash dozed down to the lower edge; in an equal width to the north the taller trees were removed; in the other cuttings, only the strip was cut.

Slightly more than half the increase in snow accumulation in the wall-and-step cutting was found within the cut strip. The wall-and-step treatment with slash lopped and scattered gave 0.2 inches less snow and with slash piled gave 0.4 inches less snow than where the slash was dozed downhill.

The increase in total snow accumulation of 25 percent for the forest as a whole by the simulated wall-and-step cutting is important to management for water. The persistance of 70 percent of the increase (3.3 inches) as delayed melt is also encouraging. The concomitant reported benefits of "little or no blowdown in the severe October storm" and "an economical logging show" suggest the treatment method is feasible.

Henry Anderson, Allan West, and
Franklin Adams

LOWER CONIFER ZONE

The first year of the calibration phase of the Caspar Creek stream gages has been completed. The level of the splash dams below the weirs (for the passage of salmon upstream) was lowered to correct the problem of submergence at high flows.

Gene Kojan has embarked on the first stage of his studies of mass movement of soil and fractured rock. He is currently pushing to get his first experimental site installed before the winter rains force him out of the drilling business. For this work the Project acquired a Mobile B-27 drilling rig mounted on a one ton "4x4" truck. This unit is equipped for augering or core drilling. The first site is located nearby in the Berkeley Hills and will serve as an outdoor lab to refine experimental procedure and to select soil tests most directly related to soil creep susceptibility.

The observation of soil creep rates and trajectories will involve the combined use of inclinometer holes drilled to bedrock and subsidiary, precisely surveyed stakes. Periodic resurvey of cased drill holes and stakes will provide detailed information on both surface and depth creep. In addition, intensive soil sampling and testing will be carried out.

Robert P. Crouse

Radiation Measurements

In the previous semiannual report we reported differences among almost instantaneous readings of nine Eppley and two Kipp pyranometers of plus four percent to minus seven percent when each Eppley or Kipp was compared to an Eppley "Smithsonian sub-standard." Subsequent comparative measurements indicated even greater differences for lower solar altitudes. We decided to run a special check of the calibration coefficients of the pyranometers at Blue Canyon airport, elevation 5,280 feet in the Sierra Nevada; the site is above much of the atmospheric turbidity and pollution which is characteristic of the Bay Area, the Central Valley, and the Sierra Nevada foothills.

At Blue Canyon airport on two clear days in summer, instantaneous millivolt outputs were measured with a Rubicon potentiometer. Each sequence began with a reading from the sub-standard, followed by the first Eppley, then another reading of the sub-standard, then the second Eppley, and so on. Altogether, 35 series were obtained over a wide range of solar altitudes. After averaging the two sub-standard readings which bracketed each Eppley or Kipp reading, linear regressions of millivolt output against global radiation calculated according to the sub-standard and "new" calibration coefficients were obtained for each sensor.

Since the comparison runs at Blue Canyon airport, we have had one opportunity to check the representativeness of some of the new or corrected calibration coefficients of the Eppleys. In informal cooperation with the Department of Agricultural Engineering and the Department of Irrigation, University of California at Davis, we participated in a comparison test of "all-wave" Beckman & Whitley and Schulze radiometers during August using automatic data recording equipment. Four Eppleys were utilized to measure global radiation during the run. For the high-sun period between 0900 and 1500 hours PST, when solar altitudes ranged between approximately 40 and 65 degrees, the range about the mean of the four Eppleys was plus or minus two percent. At lower solar altitudes, the range about the mean increased to a maximum of about plus or minus five percent. Perusal of the data indicates that much of the remaining variability may be due to the effects of ambient temperature and imperfect cosine law response.

The field operation at Davis was our first comparative experience with the all-wave Schulze radiometers. The data have not been completely processed or analyzed as yet. However, incomplete data appear to indicate that there may be need for different calibrations for short- and long-wave radiation. This problem was explored carefully by Professor H. Hoinkes of the University of Innsbruck, Austria, and reported at the IUGG meetings at Berkeley during August.[1/] Hoinkes says that a paper dealing only with calibration of the Schulze radiometers will soon appear in the Archiv für Meteorologie, Geophysik, und Bioklimatologie, Serie B.

Exploratory measurements of transmission, the proportions of global, or short-wave solar radiation, transmitted through crowns to the forest floor below, have been initiated in a dense plantation-like stand of Monterey pine. The stand was planted about 30 years ago for watershed protection. The trees average between 30 and 40 feet in height, the crown averages about 20 to 30 feet in thickness. In the immediate vicinity of the site basal area per acre is approximately 125 square feet, and stem density per acre is about 2,200 inches. The site was selected to approach minimum transmission values for stands of the Lower Conifer Zone.

Nine Eppleys were set out on the forest floor in a systematic arrangement within a square plot with side dimensions of 30 feet. Instantaneous measurements of transmitted global radiation, and global radiation sensed by a Kipp solarimeter at a nearby open field, were obtained at 10 and 15 minute intervals on several clear days with the Rubicon potentiometer.

[1/] W. Ambach & H. Hoinkes, "The Heat Balance of an Alpine Snowfield," International Association Scientific Hydrology, Publication No. 61, (1963), pp. 18-23.

Very preliminary analyses indicate the following:

1) The means transmission of global radiation is considerably affected by solar altitude. For example, mean transmission as calculated from the nine Eppleys averaged about two percent when solar altitude was about 30°. When solar altitude was about 50°, transmission averaged about 5 percent, and when solar altitude was about 70°, mean transmission increased to about 10 percent. There is, of course, a very considerable scatter about the mean however. Since most transmission studies reported in the literature are usually based on data obtained during high sun periods of summer months, most transmission estimates are higher than for year-round conditions.

2) It was also possible to separate transmitted global radiation at each of the nine sites subjectively into two components. The first component represents diffuse short-wave radiation, which is approximately analogous to shade light. The second component consists of direct short-wave radiation transmitted through openings in the crown; the direct short-wave radiation is approximately equal to the sunflecks visible over the forest floor.

   As solar altitude increases, the proportion of transmitted global radiation contributed by sunflecks increases rapidly. For limited measurements at this plot, the proportion of transmitted global radiation contributed by sunflecks amounted to about one-third when solar altitudes were less than 50°; for solar altitudes greater than 50°, the proportion of transmission contributed by sunflecks approached two-thirds. Even at this dense forest site, sunflecks accounted for more than half of transmission for an entire day in late spring.

3) One final note about the intensity of sunflecks. Although sunflecks on the forest floor appear very bright at this relatively dark and shaded site, the measured intensity of sunflecks has rarely exceeded one-half the intensity of global radiation in the open. The size and measured intensity of sunflecks are related to the height of the crown opening above the ground, to the size of the crown opening, and to the area of the sensing element. Since apparent openings in the crown at this site are for the most part smaller than the apparent disk of the sun and smaller than the size of the sensing elements, the relatively low sunfleck intensities can be explained as a mixture of shading and diffraction phenomena.

Robert A. Muller and
Clifford W. Mansfield

Soil Moisture in the Lower Conifer Zone

Initial installation of neutron probe access tubes for a study of soil moisture storage and depletion was completed during the summer at the Challenge Experimental Forest. Conditions at Challenge are representative of the optimum level of timber-production land in the Sierra Nevada. This is an area of deep soil, high precipitation, high temperatures, long growing seasons, and rapid timber growth. Later we will initiate a study of the low quality timber production lands where moisture conditions become limiting to timber growth.

The sites we are studying are located in mixed conifer forest stands consisting of several intensities of timber removal. Trees larger than 3.5 inches dbh were measured and tagged prior to cutting and remeasured after treatment. The intensity of cutting varies from clear cut, with all vegetation removed, to uncut stands. Basal area prior to cutting was about 250 sq. ft/acre. Access tubes have been installed to a depth of 20 feet on 21 study sites.

We now have an operating program for the IBM 1620 computer and a modified IBM 870 Document Writing System, which will take raw data in the form of neutron counts and plot graphs for each sampling point and each study site in terms of percent volume moisture content by depth of measurement. Included on the graph is a print out of the average of all sampling points per study site in percent volume moisture content for each depth and a cumulative average as depth increases.

Robert R. Ziemer

SAN DIMAS EXPERIMENTAL FOREST

Trapezoidal Flume Model Study

In cooperation with the Los Angeles County Flood Control District, we ran several hydraulic model tests on our flumes that were installed since the fire. All flumes are 30 feet long, 25 feet high, have 1.5:1 side slopes, and are set on approximately a 5 percent slope. They are constructed of either reinforced gunite or reinforced soil cement and can be installed at a reasonable cost. We have two types; those with an invert width of 0.5 feet installed in 25 watersheds and those with an invert width of 2 feet constructed in 11 watersheds. All flumes have soil cement transitions added to direct flow into the flume.

The model tests on the large and small flume consisted of having a control section at the flume inlet and varying the approach flow conditions. The conditions tested were: (1) subcritical approach velocity considerably less than critical velocity, (2) a subcritical approach velocity near critical velocity, (3) a supercritical approach

velocity near critical velocity, and (4) a supercritical approach velocity considerably greater than critical velocity. For each condition a rating curve was obtained. The curves seem to be in relatively close agreement with no consistent variation between supercritical and subcritical approaches. However, the rating curves may not be valid when applied to field runoff data containing appreciable debris quantities.

We are presently calculating actual peak flow data measured in the study watersheds. The data seem to be in close agreement with the model rating curves.

Jay S. Krammes

WATERSHED MANAGEMENT RESEARCH, HAWAII

Soil Erodibility

Gathering of soil samples for the soil erodibility study was completed during the summer of 1963. Seventy-five sampling sites (365 individual soil samples) were selected along 26 trails or roads from the Waianae and Koolau Mountain Ranges on Oahu. The soils were sampled under tree, shrub, or grass cover under varying isohyetal, aspect, and slope conditions (30-60 percent but sometimes steeper). The parent materials of the watershed soils are mainly basaltic flows, pyroclastic deposits, or other detrital materials.

The soils aggregate stability is tested by the wet sieving technique using aggregates initially passed through a 7.93 mm. sieve, and the results expressed as mean weight-diameters or percent distribution of certain aggregate sizes.

An inspection of our limited preliminary data shows the following results:

(1) On some transects mean weight-diameters appear to increase with increasing rainfall with a decrease in aggregates smaller than 0.50 mm. On other transects there is no apparent change in mean weight-diameter but there is an increase in aggregates less than 0.50 mm. in size; while on other transects we find a decrease in mean weight-diameter with increasing rainfall with an increase in aggregates less than 0.50 mm. in size.

(2) Generally we found larger mean weight-diameters on steep slopes (60 percent or greater).

(3) Unconsolidated ash soils, with low bulk density, have the smallest mean weight-diameters with aggregates less than 0.50 mm. exceeding 50 percent.

(4) Mean weight-diameter from soils developed from cinders is larger and the aggregates resist slaking as do soils from basalt flows.

Our preliminary work with dispersion ratios has shown that in general Hawaiian soils do not disperse easily. Our present data on mean weight-diameters show that in all probability the average mean weight-diameters will range from about 3.5 to 4.5 mm. in size. However, our rugged topography is in itself strong evidence that severe erosion will result without overhead protection. In many areas outside of the forest boundaries the soils are severely eroded.

At the higher elevation where slopes are exceedingly steep, the bedrock is capped with thin detrital material. These steep slopes (100 percent plus) are often subjected to soil avalanches which appear to be normal processes and not the result of trail cutting or other human activity. This illustrates the importance of slope in any soil erosion problem.

T. Yamamoto

Evapotranspiration Study

The evapotranspiration study is still underway in Hawaii. Water losses for the summer of 1963 for the same sites as reported earlier in the April-September semiannual report follow:

	Total water content to 10.5 ft. depth		Decrease in water content for interval	Rainfall for interval
	Early May	Early Sept.		
	(inches)			
Cover type:				
Paper bark	53.3	42.2	11.1	4.7
Silk-oak (1)	54.0	42.4	11.6	4.7
" (2)	56.8	43.6	13.2	7.0
Eucalyptus	59.5	46.4	13.1	7.0
Grass	56.0	49.3	6.7	4.7
Brush	58.9	48.6	10.3	7.0

The spring of 1963 was unusually wet and soil moisture depletion did not start until about the last week in April. Rainfall during the depletion period was of low intensities and generally short duration. Little, if any, of the rainfall was runoff. Consequently, most was lost through interception or evapotranspiration.

Plans now call for thorough analysis of the moisture losses as related to weather and soil factors.

Paul Duffy

Meetings

On May 15, the Forest Service in cooperation with the Hawaiian Hydrology Committee sponsored a hydrology conference. The Hydrology Committee is an informal group of people involved in research or in data collection within the hydrology field. State and federal agencies, several departments in the University of Hawaii, and private research organizations are represented on this committee.

The objective of the conference was to review past, present, and planned work in hydrology and related fields and to determine if the present programs were meeting the needs in the State. The conference agenda was built around the U. S. Forest Service problem analysis "A Program for Watershed Management Research in Hawaii." Certain individuals were requested to prepare and present statements directed at meeting the conference objective. Cooperation was good. About 30 individuals participated.

The proceedings of the meeting and a list of past, present, and future work are being compiled in a report that we hope to publish.

Paul Duffy

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SEMIANNUAL REPORT

Division of Watershed Management Research
Rocky Mountain Forest and Range Experiment Station

April - September 1963

GENERAL

For some time Marvin Hoover has wanted to return to project research. Approval has been given for him to do this effective October 1. He will be Project Leader of the "Water Yield Improvement in the Snowpack Timber Zone" project, headquartered at Fort Collins.

It was consoling to find that Marvin would still be with the Station--the Division's loss will be the Project's gain.

Herb Fletcher will return to the Station and assume the duties of Division Chief effective October 21. We are looking forward to welcoming Herb back after 8 years.

PUBLICATIONS

Decker, John P.
An analysis and simplification of the Blaney-Criddle method for estimating evapotranspiration. Res. Note RM-2, 2 pp.

Gary, Howard L.
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Lee, Richard
Evaluation of solar beam irradiation as a climatic parameter of mountain watersheds. Colo. State Univ. Hydrol. Paper 2, 50 pp. illus.

Skau, C. M., and Swanson, R. H.
An improved heat pulse velocity meter as an indicator of sap speed and transpiration. Jour. Geophys. Res. 68: 4743-4749, illus.

Worley, David P.
Determining the effect of forest management on river-basin water yields. U.S. Soil Conserv. Serv. Hydraul. Engin. meeting. New York City.

A Multipurpose Prefabricated Concrete Check Dam

Check dams of different design and material exist. But there is no check dam that combines the main important characteristics required or advantageous in gully control of wild mountain forest lands. These characteristics are: simplicity in design and construction, and the need of a small number of structural parts only.

To make the greatest use of a prefabricated check dam, the design should be applicable to additional purposes such as measurement of flows or drops in diversion and irrigation canals.

The search for a new type of check dam was guided by the following:

1. Resistance to flow and load greater than that of more simple structures.
2. Predetermined shape and dimensions of the structure.
3. Ease of installation.
4. Minimum amount of labor, equipment (no specialized machinery), and materials required on site of construction.
5. Design suitable as a basis for mass production of the check dam.
6. A multipurpose structure.

On the basis of these principles a prefabricated, partial prestressed concrete check dam was designed, built, and installed. The dam represents a gravity-type structure and consists of nine parts. Its overall length, measured at freeboard elevation, is 45 feet. The crest of the spillway is 4 feet above the original channel bottom; the freeboards are 2.5 feet high. The discharge capacity of the dam is estimated to be 350 c.f.s.

The dam was placed within 3 hours not counting time for excavation and backfill. Only one piece of equipment, a backhoe, was needed for the total job of installation. There is no hole-to-hole fitting required for the placement of the structural members. During construction emphasis is to be given only to the alignment of the piers (by eyesight) and their elevation (hand level or engineer's level). Steel loops have been attached to all concrete parts during fabrication to facilitate the handling of the structural members.

The dam wall, consisting of six main parts, is 3 inches thick and manufactured from prestressed, lightweight concrete that weighs 33 percent less than conventional concrete.

Three prefabricated piers with foundation slabs, representing one unit each, had been fabricated from reinforced conventional concrete. The upstream faces of all piers lean downstream at an angle of about 10 degrees with the vertical. This characteristic not only simplifies the design but also adds to the future protection of the installation. The water, overtopping the spillway, will hit the apron at a location further downstream from the structure than if a vertical wall were applied. A groove in the foundation slabs at the upstream footing of the piers, prevents slippage of the wall.

The design is also applicable to different types of weirs. In fact, it is advantageous to use prefabricated concrete in weir construction because forming of cutoff walls and pouring of concrete in the field is expensive and time consuming. The constructed dam represents a broad-crested weir. For this use, calibration of the weir is required to determine the head-discharge relationships. By joining the freeboard slabs in the center of the structure, the check dam can serve also as a precalibrated angle blade weir. The blade would be attached to the spillway, formed by the freeboards. In the design of the prototype the freeboards are sloped 45 degrees. Any other slope could be applied if considered in the design.

In general, it is required that cutoff walls prevent seepage of water. Swelling clays, gunite, or similar products may be used to seal the voids between the bedrock and the structure. The cracks between the wall slabs should be sealed with a flexible sealing agent. If a center pier is required for the stability of the wall, the top of the pier should be below the notch of the spillway in order not to interfere with the nap of the flow.

Burchard H. Heede

FLAGSTAFF

Binders for Charts and Computer Sheets

We have recently standardized the binders for Beaver Creek hydrologic records, and we like the new binders so well we think others might be interested in them too.

The binders are made by Wilson Jones (main office in Chicago) and are called "Grayline Nylon Post Binders." They are heavy duty, permanent-type binders which are loaded from the top and store flat (there are no protrusions which interfere with shelf storage). The flexible nylon posts make it possible to open a thick, loaded binder so that individual sheets (charts) are fully exposed and lie reasonably flat.

For computer output sheets (13-1/2 by 11 inches), we use the standard binder No. 17-1113N, price $6.50 each.

For water level recorder charts (16-1/8 by 5-3/8) we use a special order binder, No. CA59898, price $7.85 each.

For recording rain gage charts (6-3/8 by 13-1/4) we use a special order binder, No. CA59900, $7.85 each.

For hygrothermograph charts (13-1/2 by 5-1/16) we use a special order binder, No. CA59899, $8.55 each.

Our binders were ordered through a local office supply store.

Harry E. Brown

FW-1 Water Level Recorder Maintenance

Because we have twenty-one FW-1 Water Level Recorders on the Beaver Creek Project we have had more than our share of maintenance problems. Some of these are dealt with in Earl Aldon's Station Paper No. 67; others need elaboration for the benefit of other FW-1 users.

The most serious problem has been one of inaccuracy of the stage (water level) record. Careful calibration of the instrument should show agreement between the recorded water level and actual water level at 1/10-foot check points throughout all stages likely to be encountered. The calibration procedure calls for adjusting the pen so that it reverses properly on the top and bottom lines of the chart and so that the pen sweep coincides with the time line. With these conditions met a calibrating wheel is installed and is used to make marks on the chart at 1/10-foot intervals throughout the anticipated flow range. These marks should agree with the 1/10-foot lines on the chart--but we found that in many cases they didn't agree, even with the new instruments. Some of the trouble was due to the heart-shaped cam having been installed backwards, which was an easy thing to correct. Other times the trouble lay in defective machining of the heart-shaped cam, which could be corrected only by returning the entire instrument to the Belfort factory for modification and recalibration.

Altogether we have returned seventeen recorders to the factory. The accuracy requirement we have used is 3 percent, i.e., the discharge discrepancy due to instrumental error must not exceed 3 percent at any of the 1/10-foot check points.

The Belfort Company has been most cooperative in correcting their recorders on a no-charge basis.

Harry E. Brown

Comparison of Bedload Measurement Techniques

Sediment deposited in a collecting basin during the 1963 spring runoff was measured by a "before" and "after" survey and also by weighing the material. A comparison of results from the two techniques shows close agreement.

Survey points were located on a 4-foot grid, with elevations measured to the nearest 0.01 foot. At the time of the second survey, the deposit was visually delineated into the more prominent texture groups as recorded in the following table. The volumes and weights of these texture groups were obtained separately at the time of field measurement. Samples were taken from each group to obtain density, moisture content, and organic matter content.

Type of material	Survey method	Weighing method
	Weight - lbs.	
Gravel-sand	985	889
Sand	125	105
Organic matter	70	57
Total weight - lbs.	1,180	1,051

Edward A. Hansen

Field Reconnaissance of Phreatophyte Areas in Arizona

Many riparian areas in Arizona are inaccessible by roads, and vegetation characteristics and sometimes even the species present on the reaches are not known. A few of these streams are developed for fishing and recreation, however, the vast majority serve neither purpose and are presently supporting large acreages of uneconomical riparian growth. Greater knowledge of Arizona riparian areas is necessary for their proper management for water, range, agriculture, recreation, and wildlife.

This reconnaissance survey is designed to develop a relatively fast and accurate sampling technique for measuring riparian vegetation. The survey is designed to test the value of aerial photography in mapping inaccessible riparian vegetation. To accomplish this, we are making an extensive ground survey along a typical stream with the intention of later comparing this survey data with information obtained by studying large-scale aerial photographs.

Sycamore Creek, located approximately 35 miles northeast of Tempe, has been selected as our study area. We have arbitrarily divided the 30-mile reach into approximately 5-mile lengths. The number of quadrats on each 5-mile reach is determined statistically depending upon the homogeneity of the vegetation.

A total of 306 quadrats have been read. Woody vegetation on five of the six 5-mile reaches has been sampled. The sampling plots are 1/20-acre quadrats randomly located on the stream channel and on terraces bordering the stream channel. On each quadrat the number of individuals of each species and their height is recorded. Basal area at breast height is recorded for trees. An ocular estimate is made on the total cover on each quadrat. Also in the center of each quadrat a canopy camera photo is taken. The photo taken by this camera shows a 180-degree view above the camera. This camera is in the experimental stages of development and has not been fully tested. Eventually, we will try to correlate estimated cover with "cover" figures obtained by the camera.

Average ocular estimate of total cover tends to increase with elevation from 37 percent at the lower 5-mile reach to 29, 56, 45, and 66 percent, respectively, at the fifth 5-mile reach.

A summary of species distribution is listed on table 1. Some species such as wolfberry (Lycium andersonii), and hackberry (Celtis pallida) drop out as elevation increases. Others, principally, sycamore

(Platanus wrightii) willow (Salix gooddingii), cottonwood (Populus fremontii), ash (Fraxinus velutina), walnut (Juglans major), Utah juniper (Juniperus utalensis), wait-a-bit catclaw (Mimosa biuncifera), and skunkbush (Rhus trilobata) do not occur on quadrats below certain elevational levels.

Tamarisk (Tamarix pentandra) was recorded on all but the first reach. The 6 percent frequency on all reaches but the first one indicates its relatively low importance in comparison to existing native vegetation. As no large mature plants have been recorded or observed on this stream, the species has probably not been established for very long.

Aerial photographs of Sycamore Creek with an average scale of 1:19,000 were used to determine length of the stream channel, vegetation zones, and vegetation communities. A planimeter was used to determine area of riparian vegetation bordering the stream, number of acres of disturbed sites, and of bare ground or rock within the stream channel proper.

At some future date a special low-elevation flight designed to obtain large-scale aerial photos at selected sites on the reach will be necessary in order to identify species and determine density, frequency, height, and percent of cover.

C. J. Campbell

Effect of Soil Freezing on Water Yields and Possibilities for its Control

Frozen soils influence the disposition of snowmelt water. Concrete type of soil freezing causes increased surface runoff, whereas granular, stalactite, or honeycomb types may increase soil moisture recharge. This study was initiated to determine the effect of frozen soils on water yields from snowmelt, conditions which influence soil freezing, and possibilities for its management.

Results from the first year's data indicate that both concrete and granular types of soil freezing occur in the White Mountains of Arizona. Concrete type of soil freezing occurred to a depth of 6 inches or greater throughout the snow season in open grassland under at least 24 inches of snow. However, only granular type of freezing occurred under mixed conifer and aspen vegetation types, but ice layers were formed in the litter in these types. These ice layers were present only after thawing and freezing periods, whereas the concrete type of soil freezing was prevalent throughout the entire snow season.

		Lycium andersonii	Celtis pallida	Prosopis juliflora	Acacia greggii	Hymenoclea monogyra	Baccharis glutinosa	Celtis reticulata	Tamarix pentandra	Platanus wrightii	Salix gooddingii	Populus fremontii	Fraxinus velutina	Juglans major	Juniperus utalensis	Mimosa biuncifera	Rhus trilobata	
0-5 Mile (1500 feet)	Plants per Acre	28	6	46	32	232	0.4	0.4	-	-	-	-	-	-	-	-	-	-
	Frequency of distribution	60	9	72	62	79	2	2	-	-	-	-	-	-	-	-	-	-
	Average height	4	10	13	10	5	7	6	-	-	-	-	-	-	-	-	-	-
5-10 Mile	Plants per Acre	15	8	46	8	174	460	2	4	0.4	2	20	3	-	-	-	-	-
	Frequency of distribution	14	8	40	22	38	72	6	6	10	14	16	14	-	-	-	-	-
	Average height	3	8	9	5	4	5	7	4	8	16	4	30	-	-	-	-	-
10-15 Mile	Plants per Acre	3	9	114	13	300	386	25	1	3	1	13	1	1	-	-	-	-
	Frequency of distribution	5	2	84	30	55	80	22	6	19	30	7	7	2	-	-	-	-
	Average height	2	5	16	6	3	5	4	0.4	6	17	2	37	19	-	-	-	-
15-20 Mile	Plants per Acre	-	3	62	22	78	52	56	2	52	19	50	88	112	84	132	4	
	Frequency of distribution	-	0.7	56	31	15	26	49	6	46	38	7	46	26	35	32	7	
	Average height	-	7	4	4	3	4	3	2	10	8	24	5.0	13	9	1	3	
20-25 Mile (3900 feet)	Plants per Acre	-	-	24	7	1	55	107	1	63	2	9	54	21	145	169	115	
	Frequency of distribution	-	-	51	10	4	13	76	3	77	3	13	56	27	86	79	79	
	Average height	-	-	5	3	1	7	3	2	20	9	2	10	7	9	3	4	

Table 1.--Preliminary list of dominant species of trees and shrubs found on the lower five reaches of Sycamore Creek at elevations between 1500 and 3900 feet. Data are estimated number of plants per acre on each 5-mile reach, their relative frequency of distribution in percent, and average height in feet. A dash line indicates the species was not recorded on quadrats on the particular reach.

C. J. Campbell

Surface runoff was significantly greater on plots where concrete freezing was present. The following tabulation indicates the effect of concrete and granular types of soil freezing on the disposition of snowmelt water:

Area	Frost type	Surface runoff (Inches)	Soil moisture recharge (Inches)	Ratio: runoff to soil recharge
North-facing grassland	Concrete	2.38	3.91	0.60
South-facing grassland	Concrete	2.50	2.83	.88
Mixed conifer	Granular	.89	4.29	.21
Aspen	Granular	.47	4.45	.11

These results indicate that a greater proportion of snowmelt water leaves the area in the form of surface runoff under concrete frost than under granular frost conditions. Also, the influence of litter and vegetation types on the type of soil freezing and disposition of snowmelt water is shown in this table. Further measurement will be taken to extend these results under conditions of greater snowpacks (pending a larger snowfall this season).

There appears to be an appreciable increase in soil moisture in the 0-2 inch zone at the expense of the 3-8 inch zone. This increase is attributed to water molecules in the unfrozen zone being attracted by the ice crystals present in the frozen zone. Thus, soil moisture availability during the freezing process becomes an important factor affecting the type of soil freezing. Laboratory methods are being used to study the relationship between soil moisture and type of soil freezing. Soil temperature profiles are also being followed to determine its influence on soil freezing with particular emphasis on thawing from beneath the zone of freezing.

Present methods of land management in this area may affect the disposition of snowmelt water by influencing soil freezing. Litter removal, prescribed burning, and timber harvest methods will be studied to determine the effects of these treatments on soil freezing and thereby influencing water yields from snow.

Arnett C. Mace, Jr.

Economics of Chaparral Conversion on Three-Bar Watershed C

The 76-acre Three-Bar Watershed C has been sprayed yearly by helicopter since 1960. Accurate cost records have been maintained and provide a basis for estimating the probable expenditures required to keep the shrub canopy cover depressed to 10 percent or less. Shrub canopy cover is now approximately 7 percent. This compares with 30 percent on Watershed D where shrubs have been allowed to make natural regrowth following a wildfire in June 1959. Costs and benefits are as follows:

1. The cost of a single spray treatment is $13.42 per acre. We have sprayed four times during the past 4 years and anticipate eight maintenance spray treatments during the subsequent 26 years. The total cost of 12 such spray treatments amortized at 4 percent over the 30-year period would be $353.32 per acre.

2. The average increase in water yield (over that expected on the basis of the yield from untreated Watershed D) has exceeded 3 inches during the past two water years. Assuming 3 inches of increase in water yield for a 28-year period (no increase during the first 2 years), the shrub control treatment can be credited with 7 acre-feet of water. With a treatment cost of $353.32 per acre, the cost of additional water would be $50.47 per acre-foot.

3. The value of raw water at our weir dams is difficult to assess. However, if the increased water is given a value of $27.16 per acre-foot, and this is invested annually at 4 percent interest, the cost of the treatment ($50.47 per acre-foot) can be recovered within the same 30-year period.

The watershed was helicopter seeded in 1960. Cost of this treatment and benefits in the form of increased forage production and soil stabilization are not considered in the above calculations.

George E. Glendening

Streamflow Characteristics of Some Chaparral Watersheds

Four complete and one partial year of streamflow data have been computed for Whitespar Watersheds A and B (325 and 241 acres, respectively), Based on yields by water years, a good regression of the flow on A versus

that on B has apparently been established. Yields, however, are comparatively low (less than 1 inch) and, viewed with respect to the long-term precipitation records at nearby Prescott, possibly represent dryer year runoff. What effect a series of "wet" or "more nearly normal" years might have on the regression is not known. Some light on such an effect may be uncovered during the study on comparison of yields by storm events which is now underway.

Sediment yields to date on the Whitespar watersheds have been negligible despite some relatively high summer flows (up to 27 c.f.s.).

Streamflow on the Mingus watersheds has been very flashy and of short duration and, in contrast to the Whitespar watersheds, has been sediment laden.

Paul A. Ingebo

SEMIANNUAL REPORT

Division of Watershed Management Research
Southeastern Forest Experiment Station

April 1, 1963 - September 30, 1963

COWEETA HYDROLOGIC LABORATORY

Microclimate Relations

While net radiation is not a direct measure of Et, it certainly measures energy retention of which a major portion can be assigned to Et. We believe we can show increasing net radiation above complete covers as they vary in size from grass to high forest. The first step, a purely mechanical one, is operating a net radiometer above each of these stands in close succession. Airplane and helicopter flights were rejected on two counts: (1) expense, and (2) inability of a plane to fly close and slow enough above our small mountainous sample areas to get meaningful radiometer readings. Another conventional approach uses cumbersome, expensive towers.

Our method uses tethered surplus radiosonde balloons. A balloon is inflated with sufficient hydrogen to lift an 8-pound load of nylon cord, wire, and Fritschen-type miniature net radiometer mounted on one arm of a balanced 14-foot aluminum cross. Oscillation of the cross is damped by a restricted arc pendulum hung at its center. With cross and radiometer 25 feet below the balloon, its 6-foot diameter represents only 1 percent of the radiometer's upper viewing field.

We have ironed out some of the bugs. For instance, when the equipment was tied directly to the balloon, its weight stretched the balloon to bursting. We solved this problem by slinging the equipment load from a cheesecloth net covering the balloon. But even with this protection, fast foot and armwork are needed on a breezy day to maneuver the fragile apparatus through tree tops. So far, we've found the Thornthwaite microvolt amplifier less portable and foolproof than advertised. Two breakdowns delayed measurements, one due to transistor failure, the other due to galvanometer damage during shipping. Despite these problems, the idea has sufficient promise to be worth passing along at this preliminary stage.

Lloyd W. Swift, Jr.
James H. Patric

Plant-Water Relations

Field Measurement of Diffusion Pressure Deficit by the Dye Method

Water movement through plants occurs along a gradient of decreasing diffusion pressure deficit (DPD). The DPD is the difference in energy units between the diffusion pressure of pure liquid water and the diffusion pressure of water in plant tissue. Of several methods available for measuring DPD of plant material, the Schardakow or Russian dye method may be the most useful in the field. It requires no elaborate instruments, only very careful technique.

The Russian dye method detects changes in concentration of sucrose solutions in which plant tissue has been immersed. Parallel series of sucrose solutions covering a range of osmotic pressures (OP) are prepared in small test tubes. One series, the control solutions, is lightly colored with methylene blue; the other is an uncolored test series in which tissue samples are immersed. Solutions hypertonic to the cell sap are diluted by cell water loss, solutions hypotonic are concentrated by cell water uptake. A solution isotonic to the cell sap will remain unchanged.

Concentration changes in the test solution are detected by carefully inserting, with a medicine dropper, a drop of the corresponding colored control solution. Differences in specific gravity cause this drop to rise in concentrated solutions, to sink in diluted solutions. The solution in which the control drop neither rises nor falls is said to correspond to the DPD of the plant sample. Surprisingly, the basic sensitivity of this method of detecting changes in sugar concentrations appears to exceed that of the Abbe refractometer. Changes in OP in the order of .0025 bar can affect drop movement visibly.

However, when testing plant tissue in the solutions, there are a number of complicating factors, and several necessary precautions. The greatest difficulty occurs when cell contents and surface residues or exudates on tissues contaminate the test solution. When clean, glabrous leaves of some forest trees are used, contamination is small and immersion times of 30 minutes to an hour will compensate for it. But when surface exudates such as that on tomato leaves occur, contamination must be compensated for by longer immersion times to allow the amount of water exchange between tissue and solution to become large in relation to the amount of contamination. All glassware in contact with the solutions must be chemically clean and dry. Trial and error has shown that the leaves of several forest tree species work better when rolled and immersed without slicing the leaf, but the method works better on tomato when leaves are sliced into small squares before immersion. Which method to use--whole leaf surfaces or cut leaves--depends finally on the relation between the contamination effect and the amount of water necessary to produce a detectable change in solution concentration.

Intensive testing of the method at Coweeta and at Duke University was reported in Edward Knipling's master's thesis, "Investigation of the Schardakow method for the measurement of diffusion pressure deficit," on file at Coweeta and Duke University. To date we have not tested the method on conifers, but will be glad to correspond with anyone interested in details.

John D. Hewlett

Rainfall Interception by Hardwood Forests in Eastern United States

Only six studies have been found in eastern United States which report the amount of water intercepted by hardwood stands. I recently compared the results of these studies from publications and Coweeta files to determine whether the relation between throughfall, stem flow, and total rainfall in hardwood stands is constant during summer and winter.

Table 1 gives the authors, location, and results of each study. A linear relationship was found between throughfall and total rainfall in all studies except Coffay's. Coffay reported that his predictor was slightly improved by using a curvilinear function. Stuart's study was restricted to the summer months.

To test the agreement of the six study results applied to a range of storm sizes, a Coweeta rainfall record was chosen at random and throughfall computed by the regressions from each study. The annual record chosen had 78 storms ranging from 0.04 to 5.60 inches and total rainfall was 79.41 inches. Black's, Leonard's, Stuart's, and Loughead and Mackichan's results are in excellent agreement (Table 2). On an annual basis, results by the Maryland and the West Virginia studies indicate about 4 and 9 inches less throughfall, respectively, than the average of the other four.

Stem flow was measured in five studies. Leonard reported that stem flow averaged about 5 percent of total rainfall and that it was greatest on beech, intermediate on maple, and least on yellow birch. In North Carolina, stem flow averaged about 1 percent but it varied greatly between individual trees. In Stuart's study, stem flow amounted to approximately 2 percent of total rainfall.

Comparing these six studies is difficult, of course. For example, Coffay used 24 throughfall gages with 2.5 by 2.3-inch openings, whereas Loughead and Mackichan used six gages with 48 by 4-inch openings. Throughfall gages were periodically moved to new locations in four studies and in the others they were fixed. Trimble and Weitzman had only five throughfall gages at fixed locations. Since the main objective was to compare rainfall intensities under forest with intensities in forest openings, these workers possibly did not have enough gages to measure throughfall adequately.

Table 1.--Regression equations and confidence limits for computing throughfall

Study	Location	Regression equations		Standard error of regression	
		Summer	Winter	Summer	Winter
Black	Coweeta N.C.	$Y=0.9338x-0.0554$	$Y=0.9021x+0.0061$ [1/]	0.0536	0.0510
Coffay	Mont. Co. Md.	$Y=0.834x^{1.046}$	$Y=0.834x^{1.046}$	0.0093	0.0093
Leonard	Laconia N.H.	$Y=0.8984x-0.030$	$Y=0.9424x-0.029$	0.030	0.050
Loughead-McKichan	Asheville N.C.	$Y-0.9286x-0.0400$	$Y=0.9586x-0.0174$	0.0684	0.0466
Trimble-Weitzman	Parsons W.Va.	$Y=0.8092x-0.0164$	$Y=0.7891x-0.0062$	0.0006	0.0011
Stuart	State College,Pa.	$Y=0.888x-0.023$	None	0.0420	--

1/ 0.0061 is not significantly different from zero.

When a limited number of throughfall gages are used, the sampling error can be reduced by moving the gages between storms (Wilm, 1945) At Coweeta it was found that nine roving gages under forest cover was equivalent in error of measurement to one gage in the open.

Throughfall in mature hardwood stands of eastern United States appears from the present record to be quite uniform, only one study is out of line. Except under beech, stem flow in hardwoods may be a rather small factor in interception, but more study of stem flow in various stands and climates is indicated. When added, litter interception (see last semiannual report) also emerges as an important water cycle component, and deserves much more study.

Table 2.--Throughfall computed for a Coweeta rainfall record by six equations

Study	Throughfall	Interception plus stem flow	Throughfall
	Inches	Inches	Percent of total rainfall
GROWING SEASON			
Black	35.47	4.54	88.7
Coffay	34.30	5.71	85.7
Leonard	35.02	4.99	87.5
Loughead-MacKichan	35.78	4.23	89.4
Stuart	34.71	5.30	86.7
Trimble-Weitzman	31.83	8.18	79.6
DORMANT SEASON			
Black	35.76	3.64	90.8
Coffay	33.46	5.95	84.9
Leonard	35.87	3.53	91.0
Loughead-MacKichan	37.05	2.35	94.0
Trimble-Weitzman	30.81	8.59	78.2

Neglecting Trimble and Weitzman's equation, we hypothesize the following average throughfall equations for eastern hardwood forest (without an exceptionally dense understory such as laurel and rhododendron):

Summer	Winter
$Y = 0.9110 \times -0.04$	$Y = 0.9078 \times -0.02$

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J. D. Helvey

Soil-Water Relations

Vertical Mulching

Piedmont gullies are difficult to reclaim. In some soils, simply replanting with pine and protection will serve eventually to stabilize soil and return the area to production. In other soils, despite massive earthmoving and smoothing with heavy equipment and revegetation, new gullies often form in the lower portion of the stabilized gully. Figure 1A illustrates a typical piedmont gully in side view. Figure 1B illustrates the stabilizing treatment and Figure 1C shows the area where new gullying usually originates.

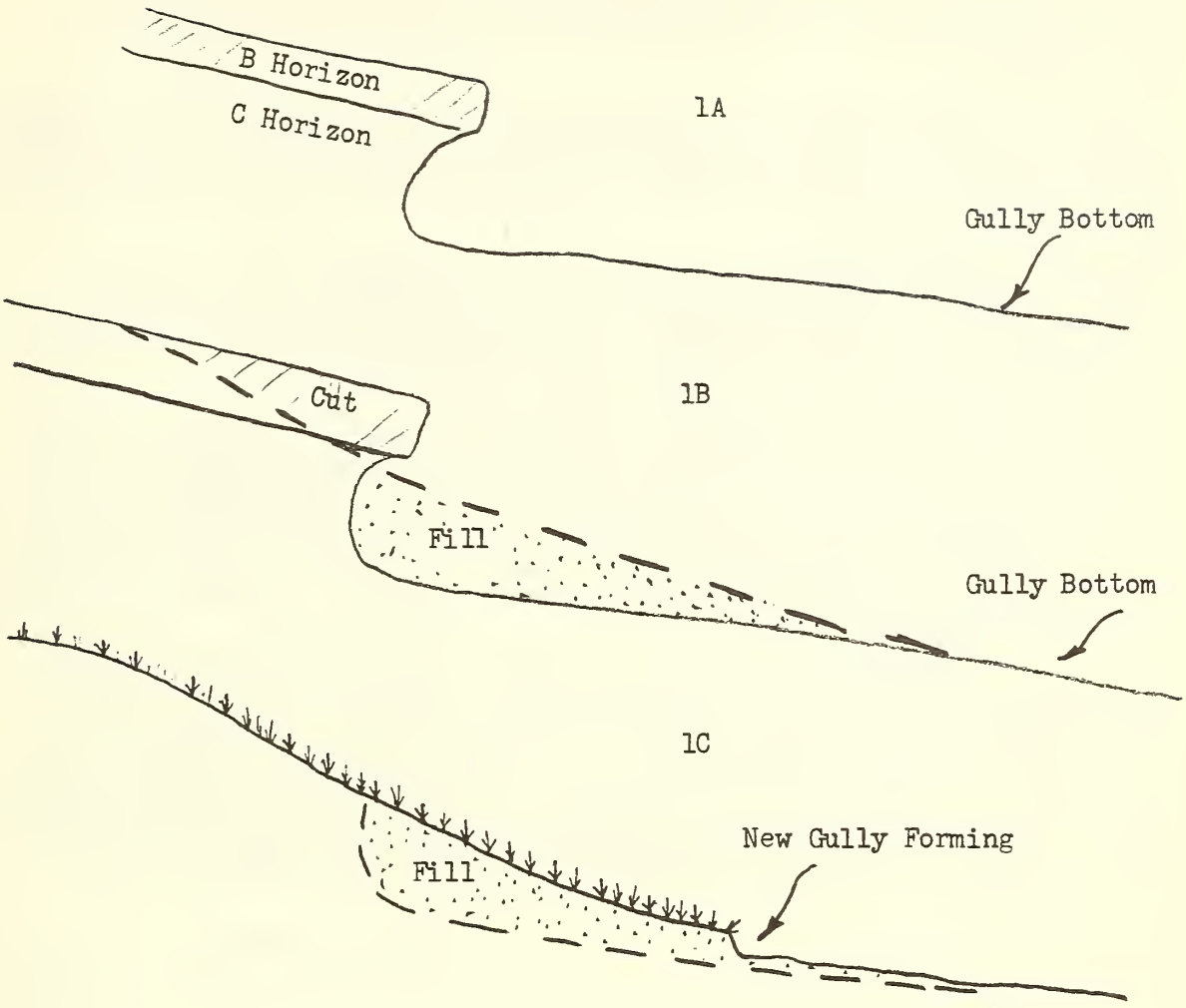

Figure 1. Schematic of a typical piedmont gully, a stabilizing treatment, and the location of usual failure.

In all cases, failure is directly attributed to low infiltration rates of the soil which, in combination with generous applications of rainfall, produce surface flow. Surface flow over this naturally erosive soil previously loosened by the smoothing operation produces a new, rapidly enlarging gully.

Obviously, surface water must be controlled if the treatment is to succeed. Diversion ditches have been used successfully in places, but these structures must be discharged where the water will cause no damage--and in the piedmont, such areas are scarce.

The most desirable solution is to increase infiltration. As a natural process, this is a slow operation, but infiltration can be increased artificially by vertical mulching. This artificial method of increasing infiltration is now being tested on piedmont gullies.

In the test, a gully was graded as in Figure 1B and then treated as shown in Figure 2, using a small ditching machine. Vertical trenches 6 inches wide and 42 inches deep were dug along the contour completely across the gully. Trenches were backfilled with sawdust (plentiful in the area) and so spaced that they can store a 2-inch rain. Exposed soil was fertilized and seeded to bermuda and lovegrass in the normal way, and pine was planted.

After one summer, the treatment looks good. The grasses have done well, and there is no indication of new gullying. However, almost all gully stabilizing treatments look good after the first growing season, and experience has shown us that success or failure cannot be measured in a single year. If this treatment appears successful after five years, then we will have confidence in recommending it as a practical method of gully stabilization in areas where planting alone has proven unsuccessful.

James E. Douglass

Discussion

It is generally agreed that engineers have dominated the science of hydrology from its beginning. This was natural and the engineering profession did a notable job up through the 1930's in reducing massive and disorganized data on rainfall, ground water, and streamflow to a set of approximate rules for use in planning water developments. Among the really important and useful simplifications were Sherman's unit hydrograph and Horton's infiltration capacity theories. These accomplishments have tended to control hydrologic thinking much as Aristotle's immense contributions dominated all science for more than a thousand years. It has been argued that the work of later hydrologists turned too much to elaboration of these early approximations and too little to the study of rainfall and runoff processes on watersheds.

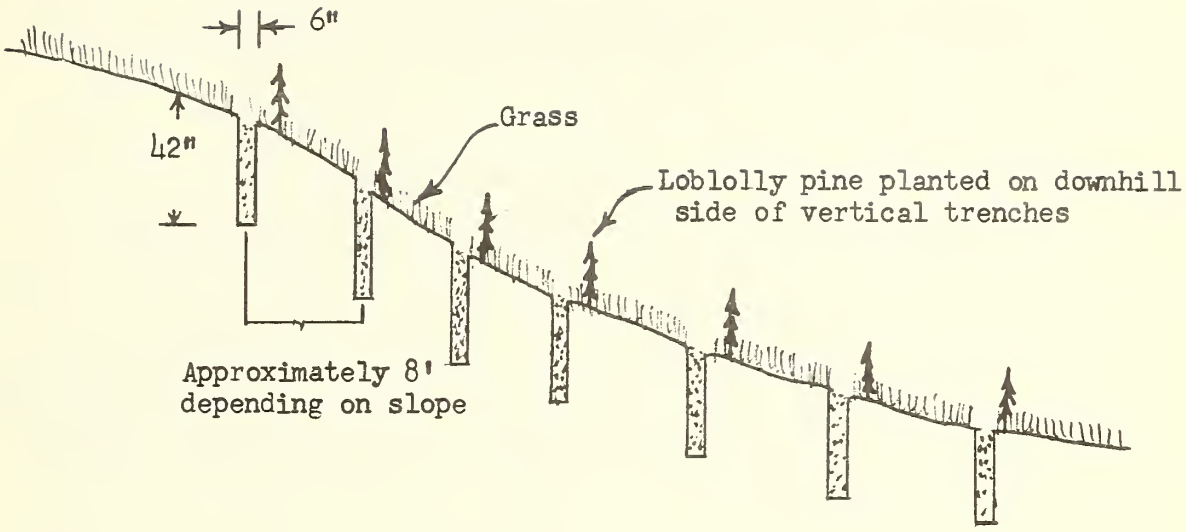

Figure 2. Schematic diagram of the vertical mulching treatment being tested.

The result has been,among other things, several peculiar and outstanding blind spots in hydrologic theory, which by incorporation into the very terminology of the science have proved as difficult to deal with as the concept of phlogiston, and have led to inadequate and erroneous descriptions of the hydrologic cycle in upstream areas.

One of these blind spots concerns the "intermediate zone" of soil water, usually mentioned briefly in the textbooks and then dismissed as of little importance, while called by Meyer 20 years ago "the no man's land of hydrology." Another is a whole complex of confusing ideas surrounding methods of hydrograph separation into surface runoff, stormflow, and base flow, most of which are based not on the study of hydrologic processes but on the hydrograph trace itself. Glossaries of hydrologic terminology reflect the confusion, shown by the tendency to avoid basic definitions in favor of defining one term relative to another (compare, for instance, the definitions in several glossaries of direct runoff, overland flow, surface runoff, subsurface runoff, interflow, return flow, storm seepage, and stormflow. Also, base flow, base runoff, ground water runoff, ground water outflow, and underflow). Many terms are intended to be descriptive of speed of travel, or source and path of flow, but the words themselves, based chiefly on speculations about the hydrograph, have often proved barriers to understanding and communication. Useful as they may have been for prediction downstream, such terms and concepts as the examples above tell us very little about the source and timing of flows through an upstream watershed. When used to "separate" and "explain" hydrographs from small watersheds, such concepts have often led hydrologists to absurd conclusions, such as a recent hydrology paper from Illinois which by conventional hydrograph separation represented overland flow as a process virtually continuous for 3 to 5 months of the year.

Nothing has brought this closer to us here than Coweeta's recent efforts to explain the source of "base" and "stormflow" in steep mountains. The question comes up repeatedly, Why don't we use "standard" hydrologic terminology? We have tried to, but where we haven't, the answer is simply that the terms do not describe the process, and that as researchers we need illumination of the process more than conformity to terminology.

Brief examination will show that available textbooks and classics in hydrology do a very poor job of describing the passage of rainwater through or over the soil mantle to the streams, although much good work is being done in various agencies in this area. In many ways, these problems are at the heart of our Forest Service hydrology research program.

What should be done? Revise hydrologic terminology as applied to upstream areas? Not yet, surely, for there isn't enough new information to form a basis. But perhaps we should avoid making the assumption that our readers will understand what we mean when we use such household terms as runoff, stormflow, and field capacity. We are learning here that explanation and communication of findings through use of everyday hydrologic terminology is a business that leads us again and again to the glossaries, and finally to Webster's Unabridged--which is perhaps the best authority after all.*

John D. Hewlett

*For example, "soil moisture" is an interesting term to play with. Dr. Charles Hursh recently told me in conversation that we were not using it as a proper hydrologic term, basing his case on its absence from the early classification of waters of the earth by hydrologists (1935). Webster's definition might be interpreted to agree with Dr. Hursh, since it appears there as "sensible dampness" or "condensation on surfaces." Many hydrologists, however, use it as synonomous with "soil water," and we have ourselves. Some of our critics have felt that to say "soil moisture moves downward" is a contradiction in terms.

New Studies

Microclimate

Effect of Forest Cover and Mountain Physiography on the Radiant Energy Balance.

Addendum: Influence of stand height on net radiation.

Addendum: Net radiation over live and deadened fescue cover.

Soil-Water Relations

Moisture Storage and Drainage of Piedmont Profile.

Addendum: Vertical mulching in piedmont gullies.

Forest Drainage

We are in the process of plotting the relationships between well water levels and a number of variables, such as distances to nearest and farthest ditches, etc., for a drainage study in wet pinelands in the Apalachicola National Forest in west central Florida. One interesting relationship which has shown up is the influence of the nearest main ditch on average water levels during the 1962 growing season.

Early in 1961 two 4.5-foot deep drainage ditches were dug 1,800 feet apart by a dragline through loamy fine sand soils that are underlain by sandy clay to clay subsoils at 20 to 40 inches. Excess surface water between the deep ditches was collected into two 1.5-foot deep secondary ditches spaced 660 feet apart. A 4-foot deep well was then installed at each of 37 locations scattered throughout the 660 x 1,800-foot block and water levels recorded at 2-week intervals thereafter.

Well readings for the 1962 growing season, March-October, were averaged and plotted against distance to the nearest deep ditch. It appeared as though the relationship was best described by a reciprocal function to which ditch distances were converted before analysis. The results of the analysis with the effects of surface elevation removed are shown graphically in Figure 1. Approximately 28 percent of the variation in well water levels was accounted for by surface elevation and distance to the nearest main ditch. This percentage should be improved by removal of the effects of the shallow collection ditches and more distant main ditch in future analyses.

Ralph A. Klawitter

Waterbalance of a Forested Coastal Plain Watershed

Defining the boundary of a watershed in the lower Southeastern Coastal Plain is at best difficult. However, with roads to act as dikes and roadside ditches to divert incoming water the job has quite handily been accomplished on a 400-acre unit on the Santee Experimental Forest. An AV3 control has been constructed at the outlet end to provide an accurate measuring device of surface runoff from the watershed.

This watershed will provide a storehouse of hydrologic data from which many investigations and studies will be derived. However, initial efforts will be concentrated towards evaluating the waterbalance on the watershed. This will be done by measurement of the variables in the following equation:

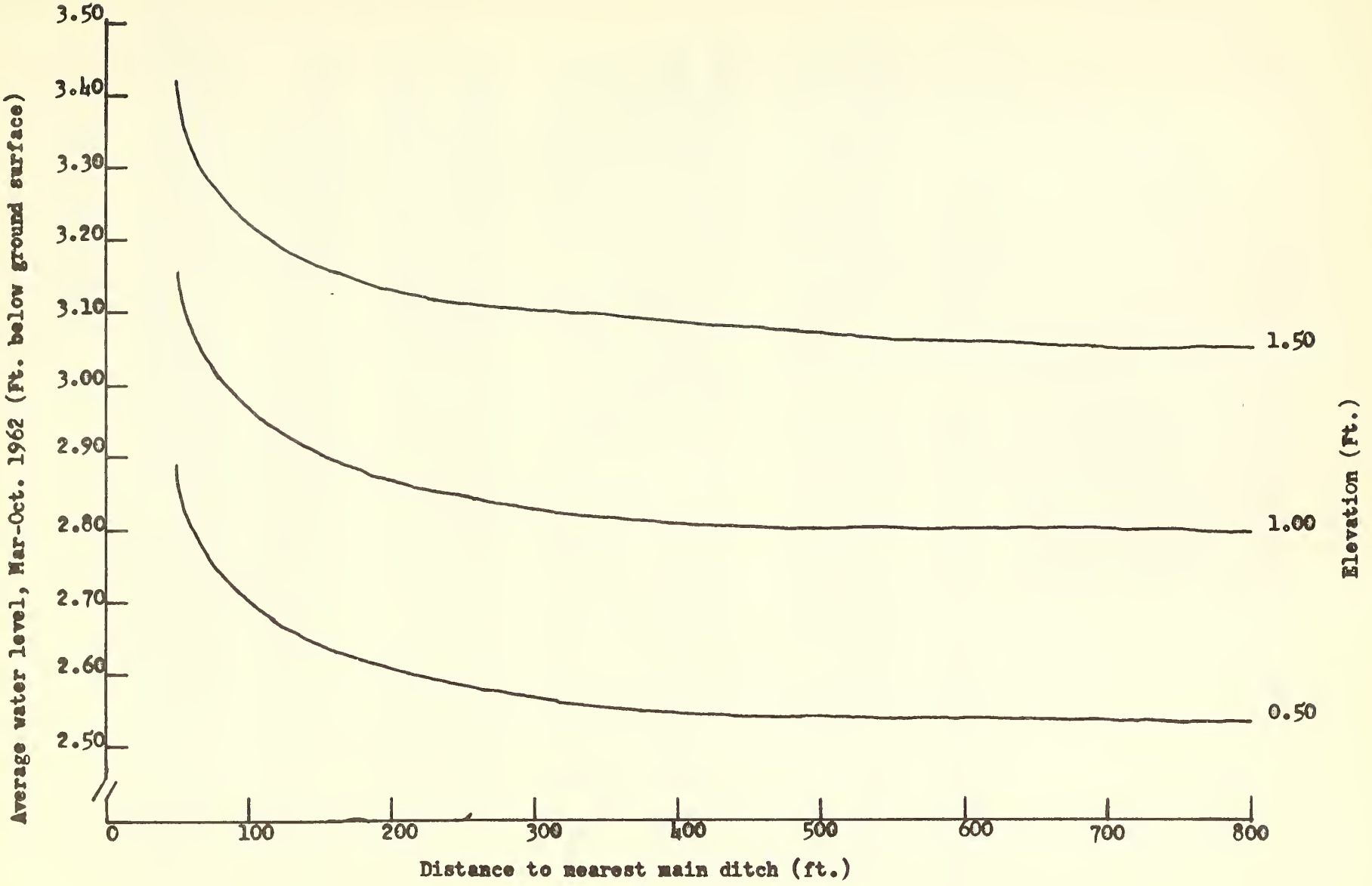

Figure 1.--The relationship of average 1962 growing season water levels to surface elevation and distance to a deep ditch on the Apalachicola National Forest.

$$P = R + \Delta \ominus + ET + \Delta S + F \Delta H$$

P = precipitation --5
R = surface runoff --1
$\ominus$ = moisture content above the water table --21
ET = evapotranspiration
S = surface storage --1
F = drainable pore space
H = water table level --21

The numbers following the above variables indicate the number of sampling points on the watershed. Except for runoff, surface storage, and percipitation, the variables will be measured every two weeks.

It is planned to rearrange the equation to solve for ET. Valid estimates of ET should be forthcoming providing subsurface losses are insignificant. ET will be calculated during periods of above, below, and average rainfall as well as seasonally when temperature plays such an important role. ET rates will also be correlated with evaporation pan data and calculated values by Thornthwaite.

The majority of the watershed falls into the very-poorly—somewhat-poorly drained SCS soil drainage classes. Timberland falling within these drainage classes has been drained by landowners for the past 15-20 years. Quite often this has been done without adequate documentation of the amount of excess water that should be removed. Data from the watershed will indicate amount and frequency of water excess to the needs of the forest and should provide sounder criteria for proper water management of this and similar type forested areas.

An accurate soils map has already been prepared for the surface four feet of the watershed. Subsurface mapping to 75 feet is also planned with the use of soil borings and electrical resistivity equipment. A complete topographic survey will be run on the watershed which together with the soils data will provide even further information for correct water management.

Subsurface flow into and out of the watershed will be investigated and evaluated should evidence of significant water movement be detected. Piezometers, water wells, and well points will be used to evaluate subsurface flow if the necessity arises.

This phase of investigation on the watershed will continue for five years or until the study objectives are fulfilled. The actual measurement of the variables other than rainfall and runoff, which have already been initiated, will begin about January 1, 1964.

Cortland E. Young, Jr.

SOUTHERN FOREST EXPERIMENT STATION
Watershed Management Research Semiannual Report

April - September 1963

General

Completion of work on old studies, some primarily for other Divisions, has continued to divert time from current watershed research. Good progress has been made, however, in organizing for new work and in the installation of new studies, including several gaged watersheds.

Bill Krumbach resigned August 17 to study for the Episcopal ministry. He has been replaced by Edwin R. Lawson, who worked with Jim Smith on several studies during Jim's assignment in Arkansas. Ed has remained in close touch with the Watershed Research in the Ozarks, and seems to be having no difficulty in shifting his sights from wood to water.

Dr. R. S. Campbell, Chief of the Division of Range and Watershed Management Research, retired on September 27. He had been in charge of the Southern Station's range research for 20 years; watershed research was added to his Division in 1955. The Campbells have moved to the new home they recently completed in Quincy, Illinois.

New Studies

FS-SO-1602-4.1	The distribution and rate of movement of percolating water in a large soil column.
FS-SO-1602-5.5	Effects of cover changes on runoff and erosion from loess and Coastal Plain watersheds.
FS-SO-1604-1.2	The effect of pine plantation management on runoff and sediment production.
FS-SO-1604-2.12	Loblolly pine plantation management demonstration on erosive soils in north Mississippi.
FS-SO-1604-2.13	A direct seeding and timber stand improvement demonstration on upland sites in north Mississippi.

Publications

In Print:

Fletcher, Peter W., and Lull, Howard W. 1963. Soil-moisture depletion by a hardwood forest during drought years. Soil Sci. Soc. Amer. Proc. 27(1): 94-98, illus.

McClurkin, D. C. 1963. Soil-site index predictions for white oak in north Mississippi and west Tennessee. For. Sci. 9(1): 108-113, illus.

Thames, John L. 1963. Needle variation in loblolly pine from four geographic seed sources. Ecology 44(1): 168-169, illus.

Ursic, Stanley J. 1963. Planting loblolly pine for erosion control in north Mississippi. U. S. Forest Serv. Res. Paper SO-3, 20 pp., illus.

Ursic, S. J., and Dendy, Farris E. 1963. Sediment yields from small watersheds under various land uses and forest covers. SFES, 9 pp., illus.

Submitted:

Blocker, Wras, and Bower, David. Filter for sampling sediment in small streams. Submitted to Agricultural Engineering.

Stearns, Forest W. Estimating solar radiation at Vicksburg, Mississippi. Submitted to North American Weather Consultants.

Krumbach, A. W., Jr., and White, D. P. Moisture, pore space, and bulk density changes in frozen soil. Submitted to SSSA for Proceedings.

Oxford Research Center

Coastal Plain Hydrology

Calibrations were completed and treatments selected for three small watersheds representing a natural grass-forb cover developed on abandoned cotton fields and three units with a cover of depleted ridge hardwoods. Two watersheds of each cover will be treated; one with loess soils, the other with predominantly Coastal Plain soils. The third watershed will serve as the control.

Both cover types will be control-burned late in 1963 as a preliminary to conversion to loblolly pine by planting. On the depleted hardwood drainages the existing overstory will be deadened in the spring of 1964. We anticipate that effects of the proposed (light) burns and the removal of hardwood overstory will show up promptly, and so will not be confused with the effect of planting, which may not be fully evident for 10 years or more.

Runoff and sediment records will be supplemented by moisture observations with neutron probe.

Management of Erosive Watersheds

Five small watersheds, 4 to 7 acres in extent, have been instrumented in 24-year-old slash and loblolly pine plantations on erosive soils in north Mississippi. Three-foot H-flumes, Coshocton sediment samplers, and ADR recorders are in use. The objectives of this study are:

1. To determine rates and amounts of surface runoff and soil losses.

2. To operate this battery of five drainage units for a period adequate for calibration.

3. Following calibration, to determine the effect of cutting the five units to various stand densities on runoff and sediment production.

Tentative plans are to treat the five watersheds after calibration as follows:

1. Check--no thinning.

2. Light thinning leaving 120 $\pm$ 5 sq. ft. basal area per acre.

3. Heavy thinning leaving 70 $\pm$ 5 sq. ft. basal area per acre.

4. Cut to a shelterwood of 35 $\pm$ 5 sq. ft. basal area per acre.

5. Clearcut all stems and replant with loblolly pine.

The Fischer and Porter ADR recorders will be operated with AC power and are geared for a 2-minute punch out. These recorders are the first of their kind. Tapes will be translated to IBM cards by the manufacturer and the data processed on a 1620 computer using a program to be adapted from one developed by the ARS Sedimentation Laboratory in Oxford, Mississippi. We hope that the bugs that may be encountered won't be insurmountable and that others can profit from our experience.

Harrison Research Center

Installation of a 4.5-H flume on a 32-acre watershed located on the Alum Creek Experimental Forest is nearing completion. The watershed incorporates three smaller watersheds (less than two acres) now being calibrated in preparation for tests of the

effects of timber cutting and prescribed burning on water flow and sedimentation. Results obtained from the small watersheds will be compared with runoff and sedimentation from the large drainage to reveal possible differences due to watershed size.

Gaged watersheds are being established on cherty, cherty limestone, and limestone soils on the Koen Experimental Forest. Three of the watersheds will be two acres or less in size and the remaining ones around 20 acres. These watersheds will be used in studies of infiltration, percolation, and moisture storage capacity of soils, as well as the effects of vegetation manipulation on runoff and sedimentation.

Field clipping and oven-dry weight determinations have been completed for the study "Vegetation Soil-Site Relationships on North Arkansas Cherty Soils." An Office Report for this study will be completed this winter.